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Plankton crustaceans in the life cycle of tapeworms occurring at Drużno Lake

[Parasitofauna of the biocoenosis of Drużno Lake — part II]

Skorupiaki planktonowe w cyklu rozwojowym tasiemców, występujących na jeziorze Drużno

[Parazytofauna biocenozy jeziora Drużno — część II]

The purpose of this work on the parasitofauna of Drużno Lake is to find out the part played by plankton *Crustacea (Cladocera, Copepoda, Ostracoda)* in the circulation of tapeworms. According to the findings of the present investigation, the definitive hosts of the tapeworm larvae found in plankton were various species of ducks.

As a resulted of the adopted method of research, the work consists of two parts. The first part is an investigation of the natural invasion of plankton crustaceans by cestode larvae. The second part consists of invading experimentally plankton crustaceans with eggs of tapeworms parasitic in ducks of Drużno Lake. The findings of the first part suggested the choise of intermediate hosts for the experiments confirmed the relations observed in natural invasions. Thus the life cycle of the investigated tapeworm species was ascertained not only under experimental conditions, but also in a particular natural biocoenosis.

The investigation was carried out during three years in following periods: 1950 — April 16 to 23; July 1 to 30; September 5 to 13. 1951 — May 7 to 13; July 6 to September 13; November 17 to 24. The experimental part was done between July 1 and September 30, 1953.

The present investigation is a part of the collective research project headed by Prof. Dr. W. L. Wiśniewski.

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Methods

Plankton crustaceans examined for the tapeworm larvae in natural invasions were collected in eight places (Wiśniewski, 21) located in different parts of the lake by means of the quantitative and qualitative methods.

The purpose of employing those two methods of collecting plankton material was to insure more precise information on the occurrence of different species of *Crustacea*, their numbers and the percentage of invasion. The quantitative method was intended to furnish data on the occurrence (in percentages) of parasites in plankton and in the particular plankton species. The qualitative method, which consisted of collecting any species in any chosen place, was to supplement the quantitative method.

Quantitative samples were collected as follows: a funnel, with an opening of a diameter measuring 25 cm, attached to a rope was lowered to a certain depth and the water was pumped through a rubber pipe into a 10 liter bottle. The shape of the funnel was intended to minimize any disturbances caused in plankton by the pumping. The samples of plankton were taken at two water levels (from the surface and from the bottom) in particular test areas. Twenty liters of water were taken at each level. Samples from two levels were sufficient since the average depth of Drużno Lake is only 1.5 m. In particularly deep places samples were taken at three levels. Plankton from each twenty liter sample was condensed by filtering the contents of the bottle through a plankton net.

The qualitative method of collecting material consisted of fishing out, by means of a plankton net attached to a rod, any quantity of plankton from a freely chosen place.

In practice it turned out, however, that in a strongly eutrophic lake, such as Drużno Lake, the qualitative method gave better and quicker results. It was probably due to the fact that the whole area of the lake resembles a rich in aquatic plants littoral. I observed that the diversity of plant communities causes a differentiation of places in which different species of *Copepoda* and *Ostracoda* occur. This concerns particularly the occurrence of *Ostracoda*. For instance *Cypridopsis vidua* (O. F. Müller) was most numerous in areas harboring *Ceratophyllum*, while *Cyclocypris laevis* (O. F. Müller) in areas containing *Lemna trisulca*.

Quantitative samples were taken in deeper places with less vegetation, while collecting crustaceans in thicket was accomplished by means of a net on a rod. This explains the differences in numbers of individuals of a particular species depending upon the mode of collection. *Macrocyclops albidus* (Jurine), *Acanthocyclops viridis* (Jur.), *Eucyclops macruroides* (Lillieborg) prevailed in qualitative samples, not only on account of the method of collection but mainly because qualitative samples were taken in a different type of environment (shallow places, covered with water plants). *Mesocyclops leuckarti* (Claus), *Mesocyclops oithonoides* (Sars) and *Eurytemora velox* (Lillieborg), on the other hand, prevailed in quantitative samples since they occurred in deeper, open parts of the lake. *Ostracoda* occurred only in qualitative samples.

Live, unpreserved *Cladocera, Copepoda* and *Ostracoda* were examined for cestode larvae. Single specimens were pipetted from a condensed sample of material and placed on a slide. The species was identified under the microscope and after squashing the specimen by pressing the cover glass, the contents of the body cavity was examined. The morphology of the larvae was also observed on fresh material as it was then best visible and the morphological details were least deformed.

The species of larvae was identified by comparing the structure of the larval scolex with the scolex of adult cestodes found in birds shot down over the lake at that time, and by comparison with larvae obtained in the experiment.

The experimental procedure applied in the second part of this work was planned with the thought of establishing suitable conditions for hosts selected for the experiment. Species of *Copepoda* and *Ostracoda* common in Drużno Lake plankton were invaded with eggs of tapeworms obtained from ducks.

The experiments were performed in 100 ml beakers filled with water from the lake. 30 examined specimens of a given species of *Copepoda* or *Ostracoda*

were placed in each dish together with tapeworm eggs. Mature eggs, containing a developed oncosphere with embryonic hooks surrounded with three shells were used for invasion. Whenever possible, eggs from a single specimen were used for each experiment in order to insure that the developing larvae really belonged to the same species. In cases where tapeworms were small and had few proglottids with mature eggs, it was necessary to use eggs of several specimens. To make results comparable each experimental invasion was repeated twice or more depending on whether it was possible to secure a sufficient number of mature eggs.

The success of the experiment, in particular the survival of the invaded *Copepoda* and *Ostracoda* required establishing suitable experimental conditions. The experimental procedure was fairly simple, but required constant care and taking many precautions in order to insure suitable experimental conditions. Best results were obtained by keeping the dishes at room temperature in normal indoor light. Adding plants like *Lemna trisulca, Lemna minor* and *Ceratophyllum,* which refreshed the water and provided rest and hiding places for the animals, was also a good practice. It made the experimental conditions more similar to natural environment. Rinsed mud was added to beakers containing species like *Acanthocyclops viridis* (Jur.) which displayed a tendency to burrow in mud. Predatory species were fed nauplius and copepodits.

In planning the experiments I intended to emphasize especially the experiments involving several species in such a combination as they appeared in the samples drawn from the water by means of a plankton net. It turned out, however, that such cultures perished quickly. After a few days only one species remained, usually the predatory one. The presence of predatory *Copepoda,* for instance *Macrocyclops fuscus* (Jur.) and also the effect of several other factors unknown to me forced me to plan experiments involving only one species.

Material

A total of 48 691 specimens of various *Copepoda, Cladocera* and *Ostracoda* species were examined. The species are listed in Table I.

The examined specimens were found to contain 228 larvae of the following parasites:

1. Metacercariae of *Bunodera luciopercae* (Müll., 1776) . . . 10
2. Metacercariae of *Gorgodera cygnoides* (Zeder) 2
3. Procercoids of *Triaenophorus lucii* (Müll.) 2
4. Procercoids of *Ligula intestinalis* (L., 1758) 2
5. Cysticercoids of *Hymenolepis compressa* (Linton, 1892) . . 2
6. Cysticercoids of *Hymenolepis paracompressa* Czapliński, 1956 32
7. Cysticercoids of *Hymenolepis paramicrosoma* Gąsowska, 1931 4
8. Cysticercoids of *Hymenolepis spiralibursata* Czapliński, 1956 15
9. Cysticercoids of *Sobolevicanthus gracilis* (Zed., 1803) . . . 5
10. Cysticercoids of *Sobolevicanthus bisaccata* (Fuhrm., 1906) . . 2

11. Cysticercoids of *Dicranotaenia coronula* (Duj., 1854) . . . 4
12. Cysticercoids of *Diorchis ransomi* Schultz, 1940 18
13. Cysticercoids of *Diorchis inflata* (Rudolphi, 1819) . . . 11
14. Cysticercoids of *Diorchis nyrocae* Yamaguti, 1935 . . . 2
15. Cysticercoids of *Diploposthe laevis* (Bloch, 1782) Jakobi, 1892 37
16. Cysticercoids of *Diploposthe skrjabini* Mathevossian, 1945 37
17. Cysticercoids of *Fimbriaria fasciolaris* (Pall., 1781) . . . 10
18. Cysticercoids of *Fimbriarioides intermedia* (Fuhrm., 1913) . 12
19. Cysticercoids of *Echinocotyle rosseteri* Blanch., 1891 . . . 2
20. Cysticercoids of *Echinocotyle clerci* Math. et Krotov, 1949 2
21. Cysticercoids of *Echinocotyle druzniensis* n. sp. 47
22. Undeveloped cysticercoids 7

Table I

Numbers of examined specimens of particular species

Species	Number of specimens examined by means of:		
	quant. method	qual. method	Total
Macrocyclops albidus	805	4398	5203
Acanthocyclops viridis	465	2394	2859
Acanthocyclops vernalis	64	266	330
Mesocyclops (s.str.) *leuckarti*	2682	1521	4203
Mesocyclops oithonoides	2053	593	2646
Eucyclops (s.str.) *serrulatus*	154	740	894
Eucyclops (s.str.) *serrulatus* var. *speratus*	105	167	272
Eucyclops (s.str.) *macruroides*	128	801	929
Eucyclops (s.str.) *macruroides* var. *denticulatus*	80	1241	1321
Eucyclops (s.str.) *macrurus*	90	860	950
Cyclops insignis	—	73	73
Eurytemora velox	915	—	915
Eurytemora lacustris	269	—	269
copepodit of *Copepoda*	8785	1927	10712
nauplius of *Copepoda*	3164	—	3164
Cypridopsis vidua	—	2992	2992
Cyclocypris laevis	—	1127	1127
Cyclocypris ovum	—	70	70
Notodromas monacha	—	610	610
Cladocera sp. div.	9152	—	9152
Total			48691

Plankton of Drużno Lake proved to be a vector of cestode larvae among which prevailed the cysticercoid type of larva.

Species of larvae found in plankton correspond to the majority of common tapeworm species found at that time in the definitive hosts. Compare the work of Rybicka (18) and Czapliński (2) dealing with this question.

An analysis of material presented in Table II entitles one to draw the following conclusions:

1. Plankton of Drużno Lake is mainly a vector of tapeworm larvae, and only to a very small extend a vector of fluke larvae.

2. The larvae occurred in species of *Copepoda* and *Ostracoda* most common in Drużno Lake (*Macrocyclops albidus, Acanthocyclops viridis, Mesocyclops leuckarti, Cyprodopsis vidua, Cyclocypris laevis*). These species contained altogether 88% of the larvae. No larvae of parasites were found in the examined *Cladocera*.

3. The findings of the study on natural invasion and the results of the experiments suggest that the above *Copepoda* and *Ostracoda* species are the main intermediate hosts of tapeworms in the Drużno Lake biocoenosis.

4. There is a clear correlation between the composition of species occurring in plankton and species of definitive hosts and their parasites. The plankton of Drużno Lake, which constitutes the main reservoir of intermediate hosts of cestodes parasitic in *Anseriformes* and *Fulica atra* consists of species typical of eutrophic lakes or of littoral of mesotrophic lakes (*Macrocyclops albidus, Acanthocyclops viridis, Mesocyclops leuckarti, Cypridopsis vidua, Cyclocypris laevis*). On the other hand the tremendous numbers of birds, especially wild ducks, inhabiting the lake is undoubtedly connected with the eutrophic character of this lake. Therefore the occurrence of larvae of wild duck tapeworms in species of *Copepoda* and *Ostracoda* typical of the eutrophic lake may be considered a sign of a long process of mutual adaptation. This shows the relation of the parasitofauna with biocoenosis of the hosts.

5. In the course of studying the occurrence of tapeworm larvae in the plankton of Drużno Lake, it was discovered that the percentage of invaded specimens in a „focus" was very high in comparison with the percentage of generally invaded specimens. For instance, in 300 *Copepoda* and *Ostracoda* occurring in a „focus" there were ten or more specimens invaded with tapeworm larvae, while in 500

specimens of the same species occurring in another place not even one larva was found.

"Foci" of invaded plankton in Drużno were most often located in shallow bays, rich in water plants and protected from waves. These places were often frequented by ducks seeking their food.

Structure and development of cysticercoid

The majority of larvae found in plankton of Drużno Lake were cysticercoids. In this paper I am concerned only with these larvae.

A cysticercoid is a larva typical of plankton *Crustacea*. A larva of this type, which has been described by Daday, Fuhrmann, Joyeux, Mrazek and Schmidt constits of a scolex bearing four suckers and a rostellum armed with hooks, two surrounding shells and a tail. The outer shell of the scolex, or the cyst, is made of compact fibrous parenchyma covered with cuticle. From the posterior end of the cyst there projects a long tail with the remaining embryonic hooks of the oncosphere. The inner shell of the scolex is made of young parenchymatous tissue containing calcareous corpuscles. It is the neck of the tapeworm.

On the basis of differences in the structure of the scolex, I distinguished in the collected material cysticercoids of 17 species of tapeworms.

The scolex of a cysticercoid is already developed and such features as the shape, number and size of rostellar hooks and the armature of suckers do not change in the definitive host.

In other words there is no fundamental difference between the scolex of a larva and of a mature cestode. Thus, by comparing the cysticercoid scolex with the scolices of adult worms, one can in many cases identify with great probability the species of the larva in question. This is the so called morphological method of determining the life cycle of tapeworms recommended by Mrazek. According to Joyeux, it often leads to errors, and should be substantiated by experiments.

My observations lead to conclude that the hooks of the scolex and the armature of suckers are the safest diagnostic features, although in some cases hooks of two different species do not show any tangible differences.

The larvae found in the collected material were identified first by means of the morphological method, and then the life cycle of

most species was confirmed experimentally. A comparison of the larvae secured experimentally with the larvae in natural invasion confirmed the identification and at the same time the life cycle of a cestode was studied not only under experimental conditions but also in a natural biocoenosis.

Schmidt (1892) was the first to describe the development of a cestode in an intermediate host, from the oncosphere to the cysticercoid. He succeeded in experimental invading *Ostracoda* with eggs of *Drepanidotaenia anatina* (Krabbe). Later works by Ruszkowski (17), Potiomkina (16) and Kisielewska (10) on the development of *Drepanidotaenia lanceolata* (Bloch) and also by Paruchin (15) give very detailed descriptions of the development of a cysticercoid in an intermediate host.

Although I did not make continuous observations on one developing specimen, the successive stages were reconstructed on the basis of appearance of particular larvae in the course of the experiment. The sequence of the stages of development which is consistent with the sequence described by the above authors is as follows: The oncosphere, having entered the body cavity of an intermediate host, grows and developes inside its spherical body cavity, which is to be the future cavity of the cyst (Plate II, Fig. 5 and 6).

Then, at one end of the larva takes place an evagination of a group of cells with embryonic hooks. The growth of this part leads to the formation of a tail. On the opposite side of the larva appears an evagination, which during subsequent stages of growth and development will give rise to the scolex and neck of the tapeworm. A division into three parts puts an end to the growth of the larva. Then follows a period of differentiation of anatomical structure. The tail, the scolex bearing four suckers and a crown of rostellar hooks, and a neck at the base of the scolex become distinguishable. Calcareous corpuscles appear on the neck region. Simultaneously, the central region undergoes a change which leads to the formation of a cyst (Plate II, Fig. 7 and 8). The walls of the cyst harden, the parenchyma becomes compact and fibrous. Only in the region where the cyst connects with the tail and neck, the wall of the cyst does not harden. The tail is made of loose parenchymatous tissue in which a channel running medially along the tail has been observed at times (Plate V, Fig. 18). The embroynic hooks susally remain at the end of the tail. Following the period of differentiation, the scolex invaginates into the cavity of the cyst. The invagination occurrs

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very rapidly, with the participation of the muscles of the neck and the scolex, and movements of the walls of the cyst. Having invaginated into the cyst cavity, the neck surrounds the scolex thus forming its inner shell. The outer shell of the scolex is formed by the cyst wall.

My observations confirm the data found in literature concerning the fact that the size of a cysticercoid may differ depending on the conditions of development and does not depend as originally suggested by Mrazek, on the time a cysticercoid remains within an intermediate host. The cysticercoids of *Hymenolepis paracompressa* Czapliński, 1956, *Hymenolepis spiralibursata* Czapliński, 1956, *Hymenolepis paramicrosoma* Gąsowska, 1931 found in naturally invaded specimens were usually single and in comparison with larvae in experimental invasions had large cysts. Regardless of their number in the body cavity of their host, the cysticercoids in experimental invasions were smaller than the cysticercoids occurring in natural invasions. One may suppose that better living conditions of a host during development of a cysticercoid also influence its size.

From the observations made on the development of cysticercoids of the same tapeworm species in different species of intermediate hosts, it appears that the thickness of the cyst wall and related to it, the size of cyst varies in different hosts and depends on the intensity of growth of the larva in the first period preceding differentiation. I observed that the cysticercoids of *Diploposthe laevis* (Bloch, 1782), *Diploposthe skrjabini* Mathevossian, 1945, *Fimbriarioides intermedia* (Fuhrm., 1913) which develop in the body cavity of *Macrocyclops albidus* have thin-walled cysts independent of the number of larvae in one specimen (Plate III, Fig. 10; Plate VII, Fig. 29), while the cysticercoids of the species undergoing development in the body cavity of *Macrocyclops fuscus* are larger and have cysts with thicker walls (Plate III, Fig. 11; Plate VI, Fig. 23). The differences in size of the larvae are early detectable. They become noticeable when a group of cells with embryonic hooks begins to differentiate (Plate II, Fig. 5, 6). During differentiation of the larva the differences are still noticeable; the central part, giving rise to the cyst, is much larger in specimens occurring in the body cavity of *Macrocyclops fuscus* than in *Macrocyclops albidus* (Plate II, Fig. 7, 8). One may suppose that conditions in the body cavity of a predatory animal such as *Macrocyclops fuscus* are favourable

to more intensive growth of larvae during the period preceding their differentiation of structure, and this causes the formation of a thicker cyst wall. Similar differences in the size of the cyst and thickness of its wall were observed in cysticercoids of *Diorchis nyrocae* Yamaguti, 1935, occurring in the body cavity of *Cypridopsis vidua* and *Cyclocypris laevis*.

The development of a cysticercoid in a laboratory lasted in summer an average of 14 days. The time of development depends on the environment; in lower temperatures and in darkness it takes a longer time. For instance, at 4°C larvae of *Diploposthe skrjabini* did not begin their differentiation period on the 14th day of development, while at 18°C and in darkness their development lasted 20 days.

Special studies are necessary in order to determine the optimal conditions for the development of cysticercoids.

Experiments on the life cycles of cestodes and description of the larvae

The life cycles of thirteen species of cestodes were tested experimentally. Different *Ostracoda* and *Copepoda* species were fed on eggs of cestodes. A positive effect was obtained in case of eleven species. Two species, namely *Hymenolepis teresoides* Fuhrm., 1906, and *Diorchis stefańskii* Czapliński, 1956, gave negative results which required repetition.

The life cycles of the following cestodes species were elucidated experimentally:

1. *Hymenolepis paracompressa* Czapliński, 1956;
2. *Hymenolepis spiralibursata* Czapliński, 1956;
3. *Hymenolepis paramicrosoma* Gąsowska, 1931;
4. *Dicranotaenia coronula* (Dujardin, 1845);
5. *Sobolevicanthus gracilis* (Zeder, 1803);
6. *Diploposthe laevis* (Bloch, 1782);
7. *Diploposthe skrjabini* Mathevossian, 1945;
8. *Fimbriaria fasciolaris* (Pallas, 1781);
9. *Fimbriarioides intermedia* (Fuhrm., 1913);
10. *Diorchis nyrocae* Yamaguti, 1935;
11. *Diorchis parvogenitalis* Skrjabin et Mathevossian, 1945.

The intermediate hosts naturally invaded with *Dicranotaenia coronula*, *Sobolevicanthus gracilis*, and *Fimbriaria fasciolaris* have been reported in literature. The cysticercoids of those three species have been described. In my experiments, however, the intermediate

hosts of *Sobolevicanthus gracilis* and *Fimbriaria fasciolaris* were not the species reported in literature, but other species commonly occurring in the biocoenosis of Drużno Lake. The life cycles of the remaining eight species have not been reported in literature, and this constitutes the first description of them.

Table III

Relation between adult worms in definitive hosts (Czapliński, 2; Rybicka, 18) and larvae occurring in intermediate hosts

Species	Number of adult worms in definitive host	Number of larvae in plankton
1. *Hymenolepis paracompressa*	16 517	32*
2. *Hymenolepis spirali bursata*	10 258	15*
3. *Hymenolepis paramicrosoma*	2 056	4
4. *Diorchis inflata*	3 130	11
5. *Diorchis brevis*	3 259	—
6. *Diploposthe laevis*	few	37
7. *Diploposthe skrjabini*	numerous	
8. *Diorchis ransomi*	1 400	18
9. *Dicranotaenia coronula*	1 046	4
10. *Echinocotyle rosseteri*	846	2**
11. *Hymenolepis compressa*	834	2
12. *Hymenolepis arcuata*	816	—
13. *Fimbriaria fasciolaris*	740	10
14. *Fimbriarioides intermedia*		12
15. *Diorchis nyrocae*	536	2
16. *Diorchis stefańskii*	458	—
17. *Sobolevicanthus gracilis*	309	5
18. *Orlovilepis megalops*	few	1
19. *Diorchis pavogenitalis*	„	—
20. *Diorchis danutae*	„	—
21. *Diorchis spinata*	„	—
22. *Hymenolepis teresoides*	„	—
23. *Sobolevicanthus bisaccata*	„	2
24. *Echinocotyle clerci*	—	2
25. *Echinocotyle druzniensis*	—	47

* — and numerous in *Gastropoda*

** — and 4 in *Gastropoda*

In addition eight species of cysticercoids found in natural invasion were identified by means of morphological comparison. They belong to the following cestodes:

1. *Hymenolepis compressa* (Linstow, 1892);
2. *Sobolevicanthus bisaccata* (Fuhrm., 1906);
3. *Echinocotyle rosseteri* Blanch., 1891;
4. *Echinocotyle clerci* Mathevossian et Krotov;
5. *Echinocotyle druzniensis* n. sp.;
6. *Diorchis ransomi* Schultz, 1940;
7. *Diorchis inflata* (Rudolphi, 1819).

1. Life cycle of *Hymenolepis paracompressa* Czapliński, 1956

(Plate IV, Fig. 12; Plate V, Fig. 18, 19)

Hymenolepis paracompressa is one of the most common cestodes of ducks on Drużno Lake. In spite of highly intensity and extensity of invasion of definitive hosts it was not easy to obtain the eggs for experimental invasion of the intermediate hosts. The worms are small, and have few proglottids with mature eggs. Furthermore the gravid proglottids break off easily during movements of the intestinal contents and in the process of selecting and cleaning the worms. Therefore, the experimental invasion had to be limited to those species in which the cysticercoids occurred in greatest numbers in natural invasion.

The eggs of *Hymenolepis paracompressa* are spherical, the oncospheres being oval. The egg shell is light and transparent, while the second shell of the oncosphere is less transparent and slightly granular (Plate IV, Fig. 12).

The eggs measure 0.079 to 0.09 mm. The size of the oncospheres is 0.033 by 0.019 mm; the embryonic hooks are 0.0066 mm long.

Specimens of three *Copepoda* species, namely *Macrocyclops albidus*, *Acanthocyclops viridis* and *Mesocyclops leuckarti* were fed on eggs of *Hymenolepis paracompressa*.

The development of cysticercoids in intermediate hosts lasted 14 days. The intensity and extensity of invasion is shown in Table IV.

The results of the experiments show that *Macrocyclops albidus* is undoubtedly the main intermediate host of *Hymenolepis paracompressa*. *Mesocyclops leuckarti* and *Acanthocyclops viridis* are auxiliary intermediate hosts.

The results of experimental invasion are consistent with the findings on natural invasions.

32 cysticercoids of *Hymenolepis paracompressa* were found in the examined naturally invaded plankton in Drużno Lake. Single specimens were found in the following species: *Macrocyclops albidus* — 17 cysticercoids; *Mesocyclops leuckarti* — 4 cysticercoids; *Eucyclops serrulatus* — 2 cysticercoids; *Eucyclops macruroides* — 2 cysticercoids.

Table IV

Species	Number of specimens			Percentage of invasion	Intensity of invasion
	fed on eggs	examined on the 14th day	invaded		
Macrocyclops albidus	40	37	37	100	3—16
Acanthocyclops viridis	40	20	18	90	1— 5
Mesocyclops leuckarti	20	15	11	73	3— 5

While studying at the same time the invasion of *Gastropoda* inhabiting Drużno Lake, Wiśniewski found cysticercoids of *Hymenolepis paracompressa* in eight snail species. The findings of his study are presented in this paper. Table V presents the intensity and extensity of invasion among the invaded species of snails.

Table V

Species	Number of specimens		Intensity of invasion
	examined	invaded	
Radix ampla Hartmann	325	50	1—20
Radix ovata Drap.	550	57	1—20
Radix auricularia L.	132	17	1— 4
Amphipeplea gluteosa Müller	70	3	single
Limnaea stagnalis L.	629	5	„
Stagnicola palustris Müller	142	1	„
Planobris planobris L.	372	1	„
Acroloxus lacustris L.	544	1	„

The intensity and extensity of natural invasion of *Gastropoda* seems to indicate that three species of snails, namely *Radix ovata*, *Radix ampla* and *Radix auricularia* play the main part in the circulation of *Hymenolepis paracompressa* at Drużno Lake. *Copepoda* species are of secondary importance.

Cysticercoids of *Hymenolepis paracompressa* have pear shaped cysts with a bowl-like invagination at the anterior end. The thick walls of the cyst are covered with a layer of transparent cuticle on the outside. The thick tail projects from the posterior end of the cyst and in many larvae a tube running through the whole tail could be observed. The embryonic hooks are usually situated at the end of the tail. The tail is on the average four times longer than the cyst. The inner shell contains numerous calcareous corpuscles. On the scolex there are four oval suckers and a rostellum bearing 10 hooks. The size and shape of hooks is the same as in an adult cestode.

The size of cysts varies within quite large limits depending on the number of larvae in the host and also possibly on the living conditions of intermediate hosts during the growth of the larva. The fact that even single cysticercoids developing in experimental invasion have smaller cysts than the cysticercoids occurring in naturally invaded specimens seems to justify such a conclusion.

Dimensions of a cysticercoid: the cyst measures 0.18 to 0.32 by 0.14 to 0.27 mm; suckers — 0.023 by 0.07 mm. Hooks vary in length from 0.053 to 0.059 mm, 0.056 mm on the average. The blade of the hook is elongated and measures 0.023 to 0.024 mm in length. The guard is small.

2. Life cycle of *Hymenolepis spiralibursata* Czapliński, 1956

(Plate IV, Fig. 15, 16)

Hymenolepis spiralibursata similarly to *Hymenolepis paracompressa* is one of the most common and numerous cestodes of wild ducks at Drużno Lake. Difficulties encountered in obtaining eggs for experimental invasion were similar to those enumerated above. Only two *Copepoda* species were invaded: *Macrocyclops albidus* and *Acanthocyclops viridis*. The eggs of *Hymenolepis spiralibursata* do not differ from the eggs of *Hymenolepis paracompressa*.

The development of cysticercoid lasted 14 days. The results of invasion are presented in Table VI.

Both *Copepoda* species are undoubtedly the intermediate hosts of *Hymenolepis spiralibursata*.

The examined plankton of Druzno Lake contained 15 cysticercoids which were identified as cysticercoids of *Hymenolepis spiralibursata*. Only one cysticercoid appeared in each specimen of host:

Table VI

Species	Number of specimens			Percentage of invasion	Intensity of invasion
	fed on eggs	examined on the 14th day	invaded		
Macrocyclops albidus	30	25	25	100	1—13
Acanthocyclops virdis	20	20	16	80	2— 8

Macrocyclops albidus — 9 cases; *Acanthocyclops viridis* — 3 cases; *Mesocyclops leuckarti* — 1 case; copepodit of *Copepoda* — 2 cases.

Wiśniewski, who at the same time studied the invasion of *Gastropoda* of Drużno Lake, found besides the cysticercoids of *Hymenolepis paracompressa* also cysticercoids of *Hymenolepis spiralibursata*. The intensity and extensity of snail invasion is presented in Table VII.

Table VII

Species	Number of specimens		Intensity of invasion
	examined	invaded	
Radix ampla Hartmann	325	38	1—20
Radix ovata Drap.	550	25	1—20
Radix auricularia L.	132	13	1—11
Limnaea stagnalis L.	629	1	1
Anodonta piscinalis Nilson	80	1	1

Summarizing the findings of investigation of natural and experimental invasion, it may be said that species of *Copepoda* and *Ostracoda* are the intermediate hosts of *Hymenolepis spiralibursata* and *Hymenolepis paracompressa*. Although the findings on natural and experimental invasion of *Copepoda* show that *Macrocyclops albidus, Acanthocyclops viridis, Mesocyclops leuckarti* are undoubtedly the intermediate hosts of *Hymenolepis spiralibursata*, the extensive natural invasion of three snail species *(Radix ampla, Radix auricularia, Radix ovata)* suggests that in the biocoenosis of Drużno Lake these gastropods play the main part in the life cycles of these two tapeworm species. The fact that both tapeworm species are much more numerous in the definitive hosts (Table III) than

other species having as intermediate hosts only *Copepoda* and *Ostracoda* seems to substantiate such a hypothesis. The cysticercoids occur in *Copepoda* rather rarely, and they are probably less available to the definitive hosts than the gastropods. Unfortunately, I could not, due to difficulties in obtaining eggs, experiment with invasion of *Gastropoda* or attempt to discover other intermediate hosts among *Copepoda* species. A trial invasion of a few specimens of *Ostracoda (Cypridopsis vidua, Cyclocypris laevis)* gave negative results.

The cysticercoids of *Hymenolepis spiralibursata* have large, oval cysts with thick walls. At the anterior end of the cyst there is a funnel-like invagination. From the posterior end projects a wide tail. The inner shell of the scolex contains calcareous corpuscles. The scolex bears four oval suckers, and a fairly long rostellum armed with ten hooks. The size and shape of hooks correspond to those of an adult worm.

Dimensions of the cysticercoid: the cyst measures from 0.20 to 0.30 by 0.16 to 0.24 mm; suckers — 0.06 by 0.045 mm; length of hooks varies from 0.29 to 0.32 mm.

The cysticercoids in naturally invaded specimens have, like in case of *Hymenolepis paracompressa,* comparatively large cysts.

3. Life cycle of *Hymenolepis paramicrosoma* Gąsowska, 1931
(Plate IV, Fig. 13, 14)

Eggs of *Hymenolepis paramicrosoma* do not differ from the eggs of *Hymenolepis paracompressa* and *Hymenolepis spiralibursata.* They are spherical and the oncospheres are slightly oval. The eggs measure 0.09 mm, while the oncospheres 0.028 by 0.023 mm.

Since on acount of the small size of the cestode and few mature proglottids only a small number of eggs were available, experimental invasion was limited to only 10 specimens of two *Copepoda* species and one *Ostracoda species.* The cysticeroids developed only in the *Copepoda.* All the invaded specimens of *Macrocyclops albidus* examined on the 14th day after ingesting the eggs contained 5 to 6 cysticercoids in their body cavity. The eight surviving *Acanthocyclops viridis* contained two, three and four cysticercoids. Specimens of *Cypridopsis* vidua did not contain any larvae in their body cavity.

The cysticercoids of *Hymenolepis paramicrosoma* have cysts of identical size and shape as those of *Hymenolepis spiralibursata*. More pronounced differences concern the length of rostellar hooks. The hooks of cysticercoids of *Hymenolepis spiralibursata* are 0.029 to 0.030 mm long, while those of *Hymenolepis paramicrosoma* vary from 0.036 to 0.040 mm.

In the examined samples of plankton from Drużno Lake specimens of *Macrocyclops albidus* were found to contain 4 cysticercoids of *Hymenolepis paramicrosoma*.

4. Life cycle of *Dicranotaenia coronula* (Dujardin, 1845)
(Plate VIII, Fig. 33, 34)

The cysticercoids of *Dicranotaenia coronula* have been described by Moniez and Rosseter (3). They were reported in naturally invaded specimens of various *Ostracoda* species: *Cyclocypris laevis* (O. F. Müll.), *Cyclocypris ovum* (Jur.), *Cyclocypris globosa* Sars, *Potamocypris ophthalmica* (Jur.), *Eucypris viriens* (Jur.), and *Candona candida* (O. F. Müll.).

Of all those *Ostracoda* only *Cyclocypris laevis* and a small number of *Cyclocypris ovum* were found at Drużno Lake. In the examined plankton *Cyclocypris laevis* was found to contain four cysticercoids of *Dicranotaenia coronula*.

Specimens of two *Copepoda* species and two *Ostracoda* species were invaded experimentally with eggs of *Dicranotaenia coronula*. Cysticercoids developed only in *Ostracoda*, thus confirming the relations observed in natural invasion.

The development of cysticercoids lasted 14 days. The findings are presented in Table VIII.

Table VIII

Species	Number of specimens			Percentage of invasion	Intensity of invasion
	fed on eggs	examined on the 14 th day	invaded		
Macrocyclops albidus	30	25	—	—	—
Acanthocyclops viridis	30	20	—	—	—
Cyclocypris laevis	30	28	28	100	1—4
Cypridopsis vidua	30	25	20	80	1—2

Differences in the intensity of invasion of both *Ostracoda* species show that their importance as intermediate hosts is not identical. Specimens of *Cypridopsis vidua* were only slightly invaded; also in nature they did not contain cysticercoids of *Dicranotaenia coronula*. *Cyclocypris laevis*, on the contrary, is undoubtedly an intermediate host and participates in the circulation of *Dicranotaenia coronula* at Drużno Lake.

The experiments could not be repeated, nor could other species be invaded because of rare occurrence of specimens with mature eggs in definitive hosts.

The eggs and oncospheres of *Dicranotaenia coronula* are spherical. The eggs measure 0.040 mm in diameter, while the oncospheres 0.022 mm. The embryonic hooks are 0.0066 mm long.

The cysts of *Dicranotaenia coronula* are spherically-shaped with a funnel-like invagination at the anterior end. From the posterior end of the cyst projects a short, slender tail with embryonic hooks. The inner shell of the scolex contains calcareous corpuscles. The rostellum is armed with a crown of 24 hocks. The suckers are round.

The cyst measures 0.19 by 0.19 mm while the suckers 0.03 by 0.03 mm. The hooks are 0.017 mm long.

5. Life cycle of *Sobolevicanthus gracilis* (Zeder, 1803)
(Plate VIII, Fig 31, 32, 35)

The cysticercoids of *Sobolevicanthus gracilis*, similarly to the cysticercoids of *Dicranotaenia coronula* were described by many writers. They have been found in specimens of three *Copepoda* species and many *Ostracoda*. The hosts were the following species of *Copepoda* and *Ostracoda; Copepoda: Diaptomus spinosus* Dad., *Diaptomus vulgaris* (Schmeil), and *Cyclops viridis* Jur.; *Ostracoda: Eucypris viriens* (Jur.), *Cyclocypris dispersa* Müller, *Cyclocypris globosa* Sars, *Potamocypris ophthalmica* (Jur.), *Candona compressa* Coch, *Candona rostrata* Brady, *Candona neglecta* Sars, and *Dolerocypris fasciata* Müller.

The examined plankton from Drużno Lake harbored 5 cysticercoids of *Sobolevicanthus gracilis*. They occurred in specimens of *Cypridopsis vidua*.

Specimens of two *Copepoda* species and two *Ostracoda* species were fed on eggs of *Sobolevicanthus gracilis*. The results of invasion are presented in Table IX.

It appears from this experiment that only *Cypridopsis vidua* is the intermediate host of *Sobolevicanthus gracilis*. Cysticercoids did not develop in experimentally invaded *Macrocyclops albidus*, *Acanthocyclops viridis* and *Cyclocypris laevis* although the eggs were taken from the same tapeworm specimen and the invaded specimens were fed more or less on the same number of eggs. Natural invasion of *Cypridopsis vidua* and also the results of expe-

Table IX

Species	Number of specimens			Percentage of invasion	Intensity of invasion
	fed on eggs	examined on the 14th day	invaded		
Macrocyclops albidus	30	23	—	—	—
Acanthocyclops viridis	20	15	—	—	—
Cypridopsis vidua	30	28	28	100	3—6
Cyclocypris laevis	30	26	—	—	—

rimental invasion entitle to consider this species the intermediate host of *Sobolevicanthus gracilis* in the Drużno Lake biocoenosis.

Cysts of cysticercoids of *Sobolevicanthus gracilis* are pear-shaped. The inner shell of the scolex contains calcareous corpuscles. The scolex bears four round suckers and a rostellum armed with eight large hooks. The length of hooks varies within quite large limits, even in cysticercoids developed from eggs of one tapeworm specimen; it ranges from 0.072 to 0.082 mm. The cyst measures about 0.16 by 0.14 mm, the suckers 0.064 by 0.064 mm. The tail is short.

6. Life cycle of *Diploposthe laevis* (Bloch, 1782)
(Plate I, Fig. 1, 2, 3; Plate III, Fig. 9, 10)

Eggs of *Diploposthe laevis* used in experiments on the life cycle were taken from the intestine of *Aythya ferina* (L.).

Immediately after expression from proglottids, the eggs are irregularly shaped due to creasing and wrinkling of the egg shell (Plate I, Fig. 2). In water the shell recovers its shape, eggs become round (Plate I, Fig. 3) and able to float in water. The oncosphere and both its shells are also spherical. The second shell of the oncosphere is less clear and transparent than the egg shell. The

eggs of *Diploposthe laevis* are quite large, measuring 0.18 by 0.18 mm. The oncospheres located in the centre of eggs measure 0.036 by 0.036 mm. The size of the second shell of the oncosphere is 0.059 by 0.059 mm. The embryonic hooks are quite large; their length is 0.016 mm.

Specimens of three *Copepoda* species and two *Ostracoda* species were invaded with eggs of *Diploposthe laevis*. The experiment was repeated twice during one summer. The results of both experiments were identical and are presented in Table X.

Table X

Species	Number of specimens			Percentage of invasion	Intensity of invasion
	fed on eggs	examined on the 14th day	invaded		
Macrocyclops albidus	60	47	47	100	2—1
Macrocyclops fuscus	40	32	25	75	1—4
Acanthocyclops viridis	50	35	26	74	1—6
Cypridopsis vidua	30	20	5	25	1—2
Cyclocypris laevis	30	28	—	—	—

The development of cysticercoids in hosts lasted 14 days. In both experiments specimens of *Macrocyclops albidus* were invaded with cysticercoids. 100% of specimens became invaded and the intensity of invasion of particular specimens shows that *Macrocyclops albidus* is their main intermediate host. *Macrocyclops fuscus* and *Acanthocyclops viridis* are rather auxiliary intermediate hosts.

The cysticercoids are relatively small and have thin-walled, lemon-shaped cysts. At the anterior end of the cyst there is a funnel-like invagination. From the posterior end projects a long tail, almost ten times longer than the cyst. The embryonic hooks are usually located in the distal part of the tail. The inner shell of the scolex contains calcareous corpuscles. The scolex bears four small round suckers and a rostellum armed with 10 hooks. The size and shape of hooks is the same as in an adult worm.

Cysticercoids which develop in the body cavity of *Macrocyclops fuscus* differed from the ones undergoing devedopment in the remaining species of hosts. Cysticercoids from *Marcocyclops fuscus* have thick-walled cysts which causes larger dimensions of cysts

and a spherical shape. The scolex in these cysticercoids does not fill the entire cyst cavity.

Dimensions of cysticercoids: the cysts of cysticeroids found in *Macrocyclops fuscus* measure 0.20 to 0.22 by 0.17 to 0.19 mm, while the ones found in other hosts measure 0.17 by 0.15 mm. The suckers measure 0.04 mm in diameter, the hooks 0.016 to 0.019 mm in length.

7. Life cycle of *Diploposthe skrjabini* Mathevossian, 1945

(Plate II, Fig. 5, 6, 7, 8; Plate III, Fig. 9, 10, 11)

The invasion experiments were repeated several times. Eggs used in the experiments came from *Diploposthe skrjabini* found in the intestine of *Aythya nyroca* (Güld.). Eggs of *Diploposthe skrjabini* do not differ from the eggs of *Diploposthe laevis*. The eggs of both species belonging to the genus *Diploposthe* are very large and spherical. They are as large as the cysts of developed cysticercoids and the length of embryonic hooks of the oncosphere equals that of rostellar hooks of an adult worm. It is surprising that the penetration of the intestinal wall of the intermediate host by over a dozen oncospheres with such large hooks at one time does not cause noticeable disturbances in the organism of the host.

Species of *Copepoda* and *Ostracoda* common in the plankton of Drużno Lake were invaded with eggs of *Diploposthe*. The experiment was repeated several times giving identical results presented in Table XI.

Table XI

Species	Number of specimens			Percentage of invasion	Intensity of invasion
	fed on eggs	examined on the 14 th day	invaded		
Macrocyclops albidus	90	80	80	100	3—2
Macrocyclops fuscus	60	55	25	45	1—5
Acanthocyclops viridis	60	40	25	63	1—5
Cypridopsis vidua	60	15	11	63	1—3
Cyclocypris laevis	60	45	15	33	1—2
Mesocyclops leuckarti	30	57	1	2	1

The development of cysticercoids in all hosts species took 14 days. The time of development of a cysticercoid depends, as could be expected, on temperature. At 4°C 14 day old larvae were spherically-shaped. At 18°C and in darkness the development lasted 20 days.

The cysticercoids developing in the body cavity of *Macrocyclops albidus, Acanthocyclops viridis* and *Mesocyclops leucarti* had thin-walled cysts, while the cysticercoids from *Macrocyclops fuscus* were larger and their cyst walls were comparatively thick. Figures 5, 6, 7 and 8, Plate II, ilustrate the particular stages of growth and development of a cysticercoid in *Macrocyclops albidus* and *Macrocyclops fuscus*. On the sixth day the larvae were still spherical, the ones developing in the body cavity of *Macrocyclops fuscus* were already much larger than others. During the differentiation of structure these differences became even more prominent. The central part, giving rise to the cyst, was much larger in larvae from the body cavity of *Macrocyclops fuscus*. Development of the scolex and its invagination into the cyst cavity occurred simultaneously in both host species. Differences in size and thickness of cyst depend on the rate of growth of the larva preceding the period of differentiation. Conditions in the body cavity of *Macrocyclops fuscus* were responsible for more intensive growth of the larva before its structure differentiation which in turn caused the formation of large, thick-walled cysts.

No difference was observed between the structure of cysticercoids of *Diploposthe laevis* and *Diploposthe skrjabini*, and therefore, in studies in the natural invasion of plankton in Drużno Lake (Table II) they could not be exactly identified. The examined plankton samples contained 37 cysticercoids of both *Diploposthe* species. They occurred singly in the same hosts as in the experiments. 20 specimens occurred in *Macrocyclops albidus*, 10 in *Acanthocyclops viridis*, and 7 in *Mesocyclops leuckarti*.

On the basis of studies of natural invasion and results of experimental invasion these *Copepoda* species may be considered the intermediate hosts of both species of *Diploposthe*. It may further be said that they participate in the circulation of cestodes in Drużno Lake.

8. Life cycle of *Fimbriaria fasciolaris* (Pallas, 1781)

(Plate VII, Fig. 26, 27, 28; Plate VI, Fig. 22)

Eggs of *Fimbriaria fasciolaris* obtained from the intestine of *Anas platyrhynchos* (L.) were used in the experiment.

Upon leaving the uterus, the eggs of *Fimbriaria fasciolaris* remain connected with one another, forming a thread resembling the algae. The egg shells of individual eggs are cylindrical, while the oncospheres and their two shells inside are spherical. The cylindrical egg shells are connected with one another forming a thread-like structure consisting of 4 do 10 eggs. The individual eggs measure 0.09 by 0.28 mm, the second shell of oncosphere 0.08 by 0.08 mm, while the oncospheres measure 0.039 by 0.039 mm. The oncospheres bear three pairs of embryonic hooks, 0.007 mm long.

Specimens of two *Copepoda* species and two *Ostracoda* species were invaded with eggs of *Fimbriaria fasciolaris*. The development of a cysticercoid lasted 14 days. The intensity and extensity of invasion is presented in Table XII.

Table XII

Species	Number of specimens			Percentage of invasion	Intensity of invasion
	fed on eggs	examined on the 14 th day	invaded		
Macrocyclops albidus	30	30	30	100	2—1
Macrocyclops viridis	30	20	18	90	3—7
Cypridopsis vidua	30	25	15	60	1—2
Cyclocypris laevis	30	30	15	50	1—1

Similar relations were observed in natural invasion. A total of 10 cysticercoids of *Fimbriaria fasciolaris* were found, 8 of them in *Macrocyclops albidus*, 1 in *Acanthocyclops viridis* and 1 in *Eucyclops serrulatus*. In natural invasion of *Macrocyclops albidus* the cysticercoids did not occur singly in particular specimens. One of the three invaded *Macrocyclops* harboured two cysticercoids, while the remaining two contained three cysticercoids each. This is probably due to the thread-like structure of eggs, which undoubtedly favours the simultaneous infection of a host with several oncospheres. The cysticercoids of tapeworms whose eggs are not

connected with one another were found singly in the body cavity of naturally invaded intermediate hosts.

G a r k a w i (4), who investigated a lake inhabited by ducks highly invaded with *Fimbriaria fasciolaris*, observed a high natural invasion with cysticercoids of this tapeworm. He did not, however, present any drawings or descriptions.

It is supposed that at Drużno Lake the following species serve as intermediate hosts: *Macrocyclops albidus, Acanthocyclops viridis, Eucyclops serrulatus. Ostracoda* are rather auxiliary hosts. None of intermediate hosts reported in literature *(Diaptomus vulgaris, Cyclops* sp., *Gammarus lacustris)* occurred in Drużno Lake; in some cases it occurred in such small numbers that it could be of no significance in the circulation of this cestode.

The cysts of cysticercoids of *Fimbriaria fasciolaris* are small, lemon-shaped with a funnel-like invagination at the anterior end. The tails are very long and thin. The embryonic hooks are located on the posterior, slightly dilated portion of the tail. The inner shell of the scolex contains calcareous corpuscles. The scolex fills the entire cavity of the cyst. It has four round suckers and a rostellum with hooks. The position of hooks on the rostellum differs from that of cysticercoids of the species described so far. The blade of the hooks is directed toward the anterior end, while the handle points to the posterior end (Plate VII, Fig. 28).

Dimensions of cysticercoids: the cyst measures 0.14 by 0.14 mm; the suckers measure 0.03 by 0.03 mm. The hooks are 0.019 mm long. The blade of the hook is slightly rounded measuring 0.008 mm in length; the handle measures 0.011 mm.

There are eight rostellar hooks, although certain larvae bear only six.

In one case I have found one cysticercoid lacking the rostellar hooks. In place where they usually occur there is only a thin shining ring. Indubitably it was a teratologic form (Plate VI, Fig. 22).

9. The life cycle of *Fimbriarioides intermedia* F u h r m., 1913
(Plate VII, Fig. 25, 29, 30; Plate VI, Fig. 23)

Fambriariae found in the intestine of *Aythya nyroca* (G ü l d.) inhabiting Drużno Lake differed from *Fimbriaria fasciolaris* from the intestine of *Anas platyrhynchos* (L.). On the basis of differences in anatomical structure they were identified as *Fimbriarioides intermedia;* this identification is not, however, absolutely certain.

Aside from morphological differences and specificity of occurrence there were other differences between the eggs of those two species. The eggs of *Fimbriarioides intermedia* from *Aythya nyroca* are not connected with one another. They are spherical in shape, while the oncospheres are oval. The second shell of the oncosphere is spindle-shaped. The eggs measure 0.11 by 0.11 mm, the oncospheres 0.056 by 0.049 mm. The embryonic hooks are 0.0099 mm long.

In the examined samples of plankton from the lake, I found 12 cysticercoids resembling the cysticercoids of *Fimbriaria fasciolaris* but differing from it in shape and the number of rostellar hooks. One cysticercoid occurred in each invaded specimen. They were found in five *Macrocyclops albidus*, four *Acanthocyclops viridis*, one *Eucyclops serrulatus* and two *Cyclocypris laevis*.

The cysticercoids proved to be identical with the experimentally obtained cysticercoids of *Fimbriarioides intermedia*.

Three *Copepoda* species and two *Ostracoda* species were invaded experimentally. The development of cysticercoids lasted 14 days. The results of the experiment, performed in duplicate, are presented in Table XIII.

Table XIII

Species	Number of specimens			Percentage of invasion	Intensity of invasion
	fed on eggs	examined on the 14th day	invaded		
Macrocyclops albidus	60	55	55	100	1—20
Macrocyclops fuscus	40	40	30	46	1— 5
Acanthocyclops viridis	60	40	—	—	
Cypridopsis vidua	30	30	20	66	1— 2
Cyclocypris laevis	30	20	9	45	1— 4

On the basis of the intensity and extensity of invasion, it appears that *Macrocyclops albidus* is the main intermediate host of *Fimbriarioides intermedia*, while the remaining species are probably its secondary intermediate hosts (*Acanthocyclops viridis, Macrocyclops fuscus, Eucyclops serrulatus, Cyclocypris laevis, Cypridopsis vidua*).

The size and shape of *Fimbriarioides intermedia* cysticercoids is not different from that of the *Fimbriaria fasciolaris* cysticercoids.

The cysticercoids of the two species differ only in the shape and number of rostellar hooks. The cysticercoids of *Fimbriarioides intermedia* have 10 hooks. The spine of the hook is longer and less rounded. The position of hooks on the rostellum resembles that of *Fimbriaria fasciolaris,* i. e., the hooks point toward the anterior end.

Dimensions of the cysticercoid: the cyst measures 0.14 by 0.14 mm, the suckers 0.03 by 0.03 mm. The length of hooks is constant and measures 0.02 mm. The length of the blade is 0.011 mm; the length of the handle is 0.009 mm.

The cysticercoids which develop in the body cavity of *Macrocyclops fuscus* have, similar to *Diploposthe skrjabini,* thick cyst walls, which, in turn, causes a larger size of cysticercoids, i. e., 0.17 by 0.16 mm.

10. The life cycle of *Diorchis nyrocae* Yamaguti, 1935
(Plate X, Fig. 40, 41, 42)

The eggs of *Diorchis nyrocae* have been described as oval. Such a description probably concerns eggs in which the egg shell was not visible. It is hardly noticeable in eggs crowded in the uterus and even more so in a fixed preparation. The egg shell resembles a flimsy membrane, which straightens out in water giving the eggs an elongated appearance. The oncosphere and both its shells are oval. The elongated and flimsy egg membrane is conducive to settling on water plants. Such an adaptation is connected with the mode of living of intermediate hosts. It turned out that the intermediate hosts of *Diorchis nyrocae* are *Ostracoda* living and searching for food among water plants. For instance *Cypridopsis vidua* inhabits the *Ceratophyllum* thicket.

The oncospheres measure 0.016 by 0.033 mm; the second shell of the oncosphere measures 0.083 by 0.030 mm. The eggs measure 0.41 by 0.026 mm. The embryonic hooks are 0.0066 mm long.

Two *Copepoda* species and two *Ostracoda* species were fed on eggs of *Diorchis nyrocae.* Cysticercoids developed in specimens of both *Ostracoda* species, while no *Copepoda* contained any oncospheres or cysticercoids in its body cavity.

Development lasted 15 days. The intensity and extensity of invasion is illustrated in Table XIV.

In the naturally invaded samples of Drużno Lake plankton, I found 2 cysticercoids of *Diorchis nyrocae*; one occurred in *Cy-*

Table XIV

Species	Number of specimens			Percentage of invasion	Intensity of invasion
	fed on eggs	examined on the 14th day	invaded		
Macrocyclops albidus	60	50	—	—	—
Acanthocyclops viridis	40	30	—	—	—
Cypridopsis vidua	60	50	50	100	1—6
Cyclocypris laevis	60	56	56	100	1—4

pridopsis vidua and the other in *Cyclocypris laevis*. These two *Ostracoda* species are undoubtedly the intermediate hosts of *Diorchis nyrocae*.

The cysts of *Diorchis nyrocae* cysticercoids are spherical in shape with a funnel-like invagination at the anterior end. From the posterior end of the cyst projects a long and thin tail, with embryonic hooks in its distal portion. The cysticercoids found in the two hosts species differed slightly in the thickness of the cyst wall. The larvae occurring in *Cyclocypris laevis* had cysts with fine walls, while those occurring in *Cypridopsis vidua* had thick-walled cysts.

The scolex of the cysticercoid has four round suckers armed with tiny spines. The spines form a clearly defined marginal band around each sucker. They are small and closely and regularly arranged. The rostellum of the scolex bears 10 hooks with a long, in proportion to the blade, handle.

Dimensions of the cysticercoid: the cysts of cysticercoids found in *Cyclocypris laevis* measure 0.22 by 0.22 mm, while the cysts of cysticercoids occurring in *Cypridopsis vidua* measure 0.26 by 0.26 mm. The size of suckers is 0.07 by 0.07 mm. The hooks are 0.026 mm long.

11. Life cycle of *Diorchis parvogenitalis* Skrjabin et Mathevossian, 1945

(Plate XI, Fig. 45, 47)

Specimens of three *Copepoda* species and two *Ostracoda* species were fed eggs of one specimen of *Diorchis parvogenitalis* obtained from the intestine of *Aythya ferina* (L.).

The eggs and oncospheres of *Diorchis parvogenitalis* are oval in shape and measure 0.11 by 0.07 mm and 0.050 by 0.026 mm respectively.

The development of the cysticercoid lasted 15 days. The results of the experiment are presented in Table XV.

Table XV

Species	Number of specimens			Percentage of invasion	Intensity of invasion
	fed on eggs	examined on the 14th day	invaded		
Macrocyclops albidus	30	25	—	—	—
Macrocyclops fuscus	15	13	—	—	—
Acanthocyclops viridis	30	23	—	—	—
Cypridopsis vidua	30	23	77	77	1—4
Cyclocypris laevis	30	28	—	—	—

The cysticercoids developed only in specimens of *Cypridopsis vidua*. The intensity of invasion suggests that *Cypridopsis vidua* is the intermediate host of *Diorchis parvogenitalis*, but it remains undetermined whether it is the main intermediate host. The experiment could not be repeated as the worm rarely occurred in the definitive hosts inhabiting the lake.

The cysticercoids of *Diorchis parvogenitalis* are oval, with a funnel-like invagination at the anterior end. The tails are comparatively short, only 1.5 times longer than the cyst. The thin walls of the cyst are covered with a layer of transparent cuticle. The inner shell of the scolex contains calcareous corpuscles. The surface of the four oval suckers is covered with tiny spines. The spines located on the margin of the suckers are more closely arranged and better visible. The 10 rostellar hooks are of the same size and dimensions as in an adult tapeworm.

Dimensions of the cysticercoids: the cyst measures 0.24 by 0.18 mm, the suckers 0.064 by 0.060 mm. The length of hooks varies from 0.036 to 0.039 mm. The examined samples of plankton from Drużno Lake were found to contain in *Cypridopsis vidua* 18 cysticercoids identical with the cysticercoids of *Diorchis parvogenitalis*, described above. It is probable, however, that they belonged rather to *Diorchis ransomi*, a cestode commonly occurring in *Fulica atra* (L.). The author was unable to find any criteria distinguishing the cysticercoids of *Diorchis parvogenitalis* from the cysticercoids of *Diorchis ransomi* obtained experimentally by Rybicka (18). *Diorchis parvogenitalis* rarely occurred in the definitive hosts inhabiting Drużno Lake.

12. Life cycle of *Diorchis stefańskii* Czapliński, 1956
(Plate XI, Fig. 44, 46)

The eggs of *Diorchis stefańskii* are ovally-shaped; so are the oncospheres inside them. The first shell of the oncosphere is transparent and narrowed at the poles; the second, less transparent shell is cylindrical in shape. The surface of this shell observed under high power shows regular striations resembling the striations on the shells of certain *Diatomeae*. The shell of eggs crowding the uterus is creased and hardly visible; in water it straightens out and gives the eggs their final appearance.

The eggs measure 0.14 by 0.095 mm, the oncospheres 0.056 by 0.022 mm. The second shell of the oncosphere measures 0.12 by 0.039 mm. The embryonic hooks are 0.0099 mm long.

Copepoda and *Ostracoda* common in Drużno Lake were fed on eggs of *Diorchis stefańskii*. Specimens of the following *Copepoda* species became not invaded: *Macrocyclops albidus, Acanthocyclops viridis, Mesocyclops leuckarti, Eucyclops macruroides*. The experiment was repeated several times with negative results. Only in very few specimens of *Macrocyclops fuscus* single cysticercoids developed.

Cyclocypris laevis, one of the invaded *Ostracoda*, did not become invaded with *Diorchis stefańskii* oncospheres. On the other hand the invaded *Cypridopsis vidua* contained a large number of live oncospheres in their body cavities. Examination of oncospheres in the course of the experiment revealed that the growth of the oncospheres was noticeably slowed down. On the 14th day of the experiment all the larvae were spherically-shaped, forming a vesicle with a cavity inside of it. The size of the larvae varied; some were small and undeveloped, 8 to 10 of them were several times larger than the oncospheres (0.049 to 0.082 mm) and only a few reached the size of 0.14 by 0.14 mm. On the 28th day following ingestion one of the largest larvae transformed into a cysticercoid. The rest remained alive, but did not display any differences in the rate of growth and development. On the 30th day, at the end of the experiment, single cysticercoids were found in 30% of the specimens.

The experiment shows that none of the enumerated species is the main intermediate host of *Diorchis stefańskii*. It should rather be searched for among other *Ostracoda* species.

An attempt was made at invading *Cyclocypris ovum*, but such obstacles as a large death rate during the experiment and difficul-

ties in finding them in the lake interfered with obtaining definite results. *Cyclocypris ovum* became invaded with oncospheres, but the invasion was less wide-spread than in case of *Cypridopsis vidua*; specimens of *Cypridopsis ovum* contained three or four oncospheres in their body cavities. On the 16th day of the experiment four of the surviving specimens contained developed cysticercoids. Two of them contained two cysticercoids, one contained three and finally one contained one cysticercoid.

The cysticercoids of *Diorchis stefańskii* are pear-shaped. The cyst wall is fine and covered with a fairly heavy layer of transparent cuticle. The tail is short. The cysticercoids from the body cavity of *Macrocyclops fuscus*, similar to other cysticercoid species undergoing development in this host have very thick cyst walls. The inner shell of the cysticercoid contains calcareous corpuscles. The scolex bears four large oval suckers. The surface of the suckers is covered with tiny spines, which are more closely arranged on the margins than in the centre. 10 rostellar hooks resemble in shape and size the hooks of an adult cestode. The tail is relatively short.

Dimensions of the cysticercoid: the cyst measures 0.29 by 0.26 mm, the suckers 0.10 by 0.082 mm. The embryonic hooks are 0.0066 mm long.

13. Life cycle of *Hymenolepis teresoides* Fuhrmann, 1906
(Plate VI, Fig. 24)

The eggs and oncospheres of *Hymenolepis teresoides* are spherical in shape. No transparent egg shell typical of eggs of species described so far was observable. It may be possible that the shell is extremely thin and adheres closely to the second shell of the oncosphere.

The eggs measure 0.46 by 0.46 mm, the oncospheres 0.022 by 0.022 mm. The embryonic hooks are 0.0066 mm long.

Hymenolepis teresoides is a rare parasite of the definitive hosts inhabiting Drużno Lake. Only two specimens with mature eggs were found during one summer. *Copepoda* and *Ostracoda* common in Drużno Lake were fed those eggs. The invaded *Copepoda* namely *Macrocyclops albidus, Macrocyclops fuscus, Acanthocyclops viridis* and *Mesocyclops leuckarti* did not harbor any oncospheres or cysticercoids in their body cavity. Only *Cypridopsis vidua* became invaded with oncospheres, which nevertheless developed very slowly. On the

14th day of the experiment each specimen of *Cypridopsis vidua* contained in its body cavity several live, spherical larvae measuring 0.042 mm in diameter. Some of them were a little larger, while some of the oncospheres were underdeveloped. After a month elapsed only four *Ostracoda* survived and the larvae in them remained at the same stage of development as on the 14th day. A repeated experiment gave similar results.

The examined samples of plankton from Drużno Lake did not contain cysticercoids with hooks resembling the hooks of an adult cestode. The intermediate hosts of *Hymenolepis teresoides* are therefore still unknown.

14. Cysticercoids of *Hymenolepis compressa* (Linton, 1892) in the naturally invaded plankton of Drużno Lake

(Plate IV, Fig. 17)

Two specimens of cysticercoids, one occurring in *Macrocyclops albidus*, and the other in *Mesocyclops leuckarti* differed in size and length of hooks from cysticercoids occurring in *Hymenolepis paracompressa*. Their hooks were similar to those of an adult *Hymenolepis compressa*. The length of hooks amounted to 0.050 mm.

Hymenolepis compressa rarely occurred in the definitive hosts inhabiting Drużno Lake. It was therefore impossible to trace its developmental cycle experimentally. It was eventually proved experimentally in 1955 while studying the life cycles of cestodes associated with Gołdapiwo Lake. The results of the experiments show that *Macrocyclops albidus* and *Mesocyclops leuckarti* are the intermediate hosts of *Hymenolepis compressa*.

15. Cysticercoids of *Sobolevicanthus bisaccata* (Fuhrm., 1906) in the naturally invaded plankton of Drużno Lake

(Plate VI, Fig. 20, 21)

Two specimens of cysticercoids found in the body cavity of *Macrocyclops albidus* were identified, by comparison of their scolices, as belonging to *Sobolevicanthus bisaccata*. Typical of these cysticercoids are the eight rostellar hooks of the same shape and dimensions as in an adult cestode. The cyst of these cysticercoids has thin walls and is pear-shaped with a funnel-like invagination at the anterior end. The cyst measures 0.19 by 0.17 mm. The hooks are 0.035 mm long.

16. Cysticercoids of *Echinocotyle resseteri* Blanch., 1891 in the naturally invaded plankton of Drużno Lake
(Plate IX, Fig. 36, 37)

In the examined samples of plankton I found only one cysticercoid whose scolex is identical with the scolex of a cestode identified by Czapliński as *Echinocotyle rosseteri* (2). The cysticercoid occurred on one specimen of an unidentified *Ostracoda*. On the other hand, Wiśniewski, examining the *Gastropoda* in Drużno Lake found similar cysticercoids in two specimens of *Radix ampla*. Each snail contained two cysticercoids.

The cysts of these cysticercoids are apple-shaped. Their thin walls are lined with the inner shell of the scolex containing numerous calcareous corpuscles. The scolex fills the entire cyst cavity. Four large oval suckers are armed with hooklets, which is typical of the genus *Echinocotyle*. The hooklets on suckers are arranged in the following manner: 5 rows on the inner margin of suckers, 3 on the outer margin and 2 on each pole. At the centre of the suckers there are 5 to 7 hooks arranged as illustrated in Fig. 37. The rostellum bears 10 typically shaped hooks. The blade of the hooks is short in proportion to the handle. The shape and size of hooks resembles *Echinocotyle skrjabini* described by Mathevossian and Krotov in 1949.

Dimensions of the cysticercoid: the cyst measure 0.23 by 0.23 mm, the suckers 0.11 by 0.048 mm. The hooks are 0.034 mm long. The length of the handle is 0.022 mm, while the blade is 0.013 mm long.

17. Cysticercoids of *Echinocotyle clerci* Mathevossian et Krotov, 1949 in the naturally invaded plankton of Drużno Lake
(Plate IX, Fig. 38, 39)

In the examined plankton of Drużno Lake I found twice in specimens of *Acanthocyclops viridis* a cysticercoid whose armature of the scolex resembles closely that of an adult *Echinocotyle clerci*. An adult form was not found in the examined definitive hosts inhabiting Drużno Lake.

The cysts of such cysticercoids are ovoid and have thin walls. The specimens found have no tails. The inner shell of the scolex contains calcareous corpuscles. The large scolex completely fills the entire cyst cavity. The scolex in both larvae was located crosswise as illustrated in Fig. 39. Four large oval suckers bear hooklets on

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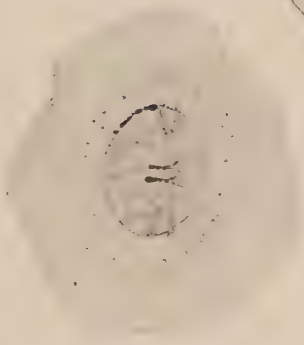

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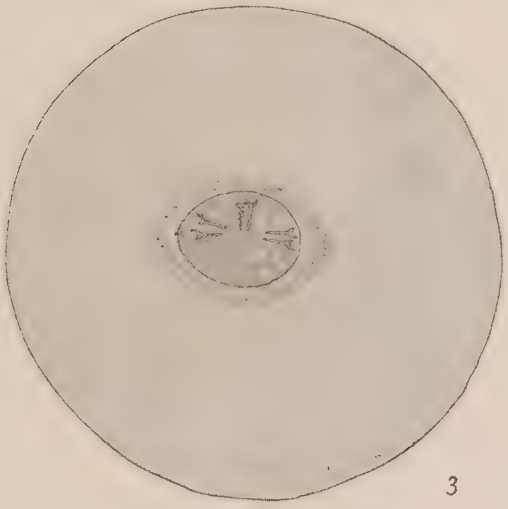

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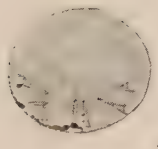

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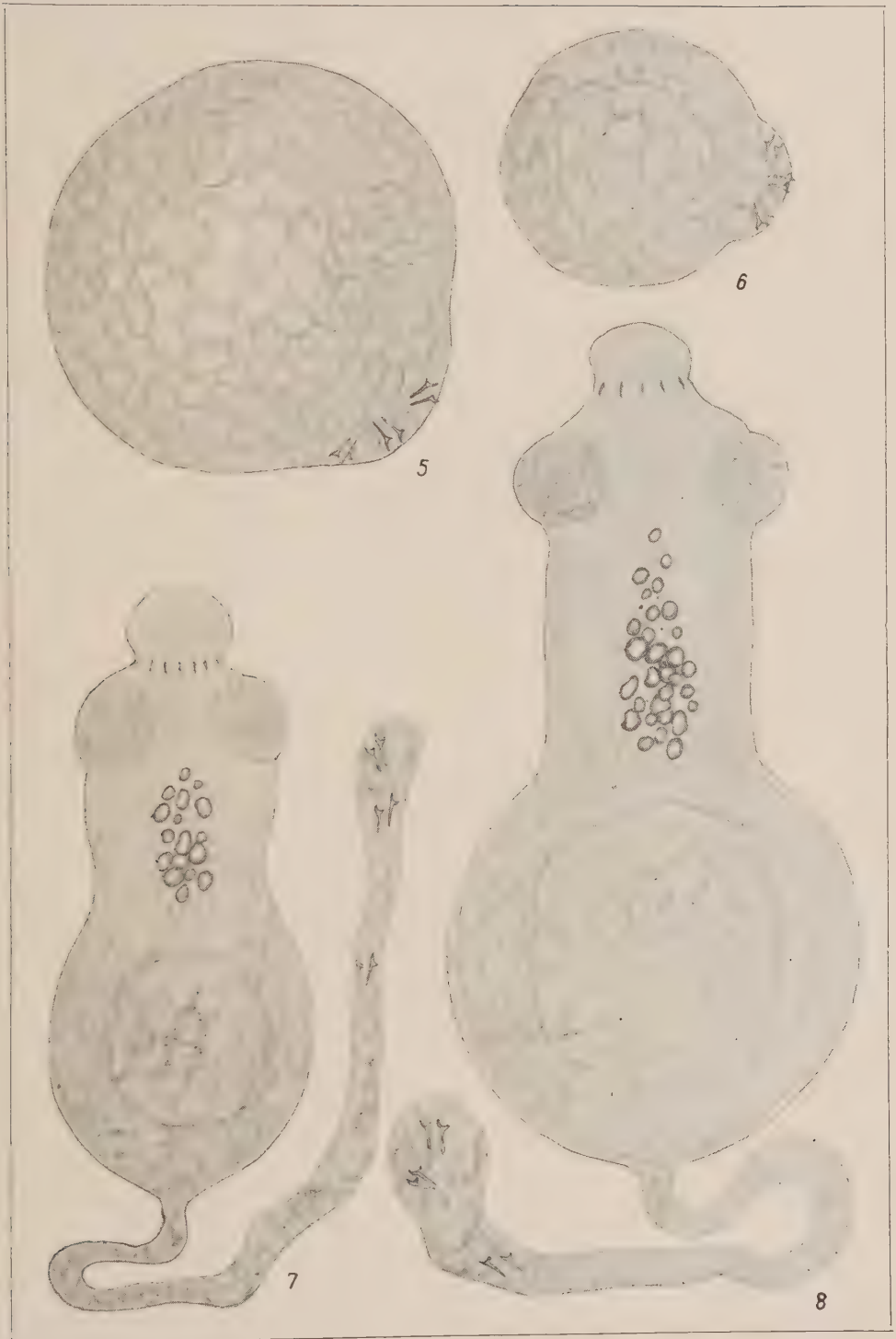

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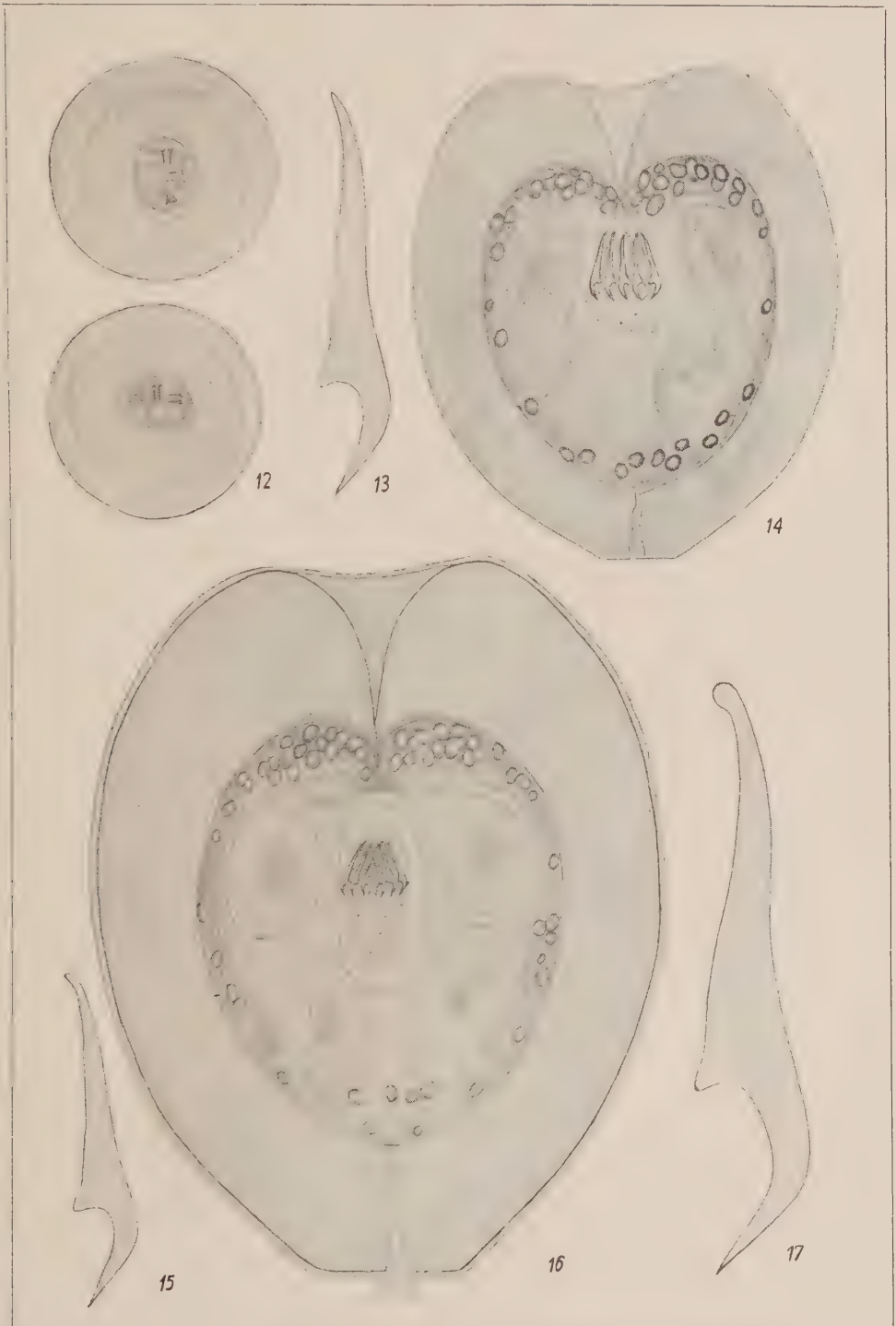

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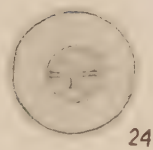

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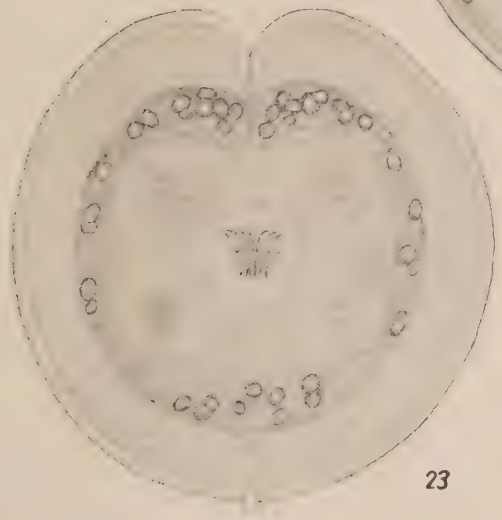

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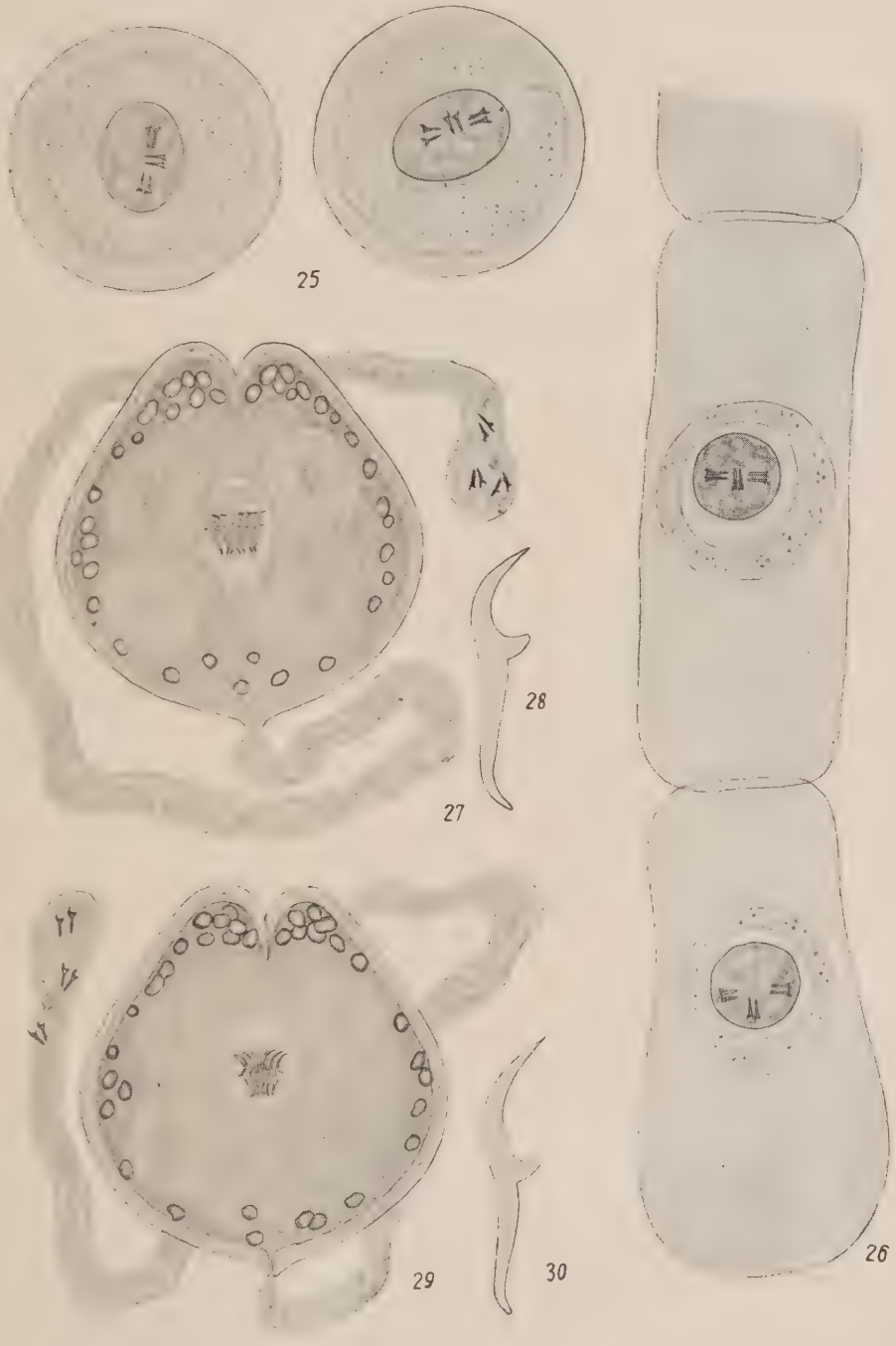

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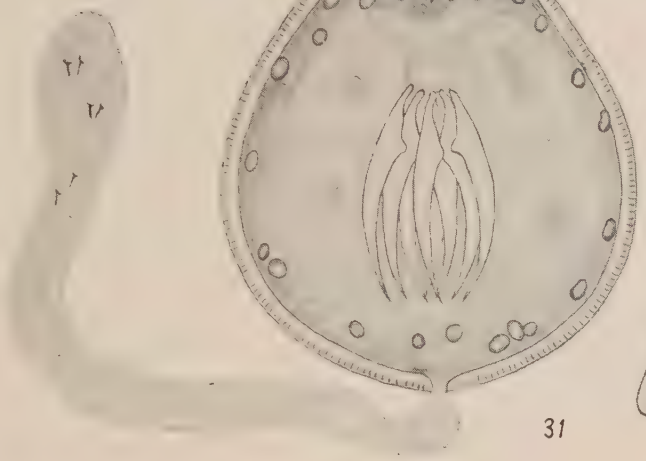

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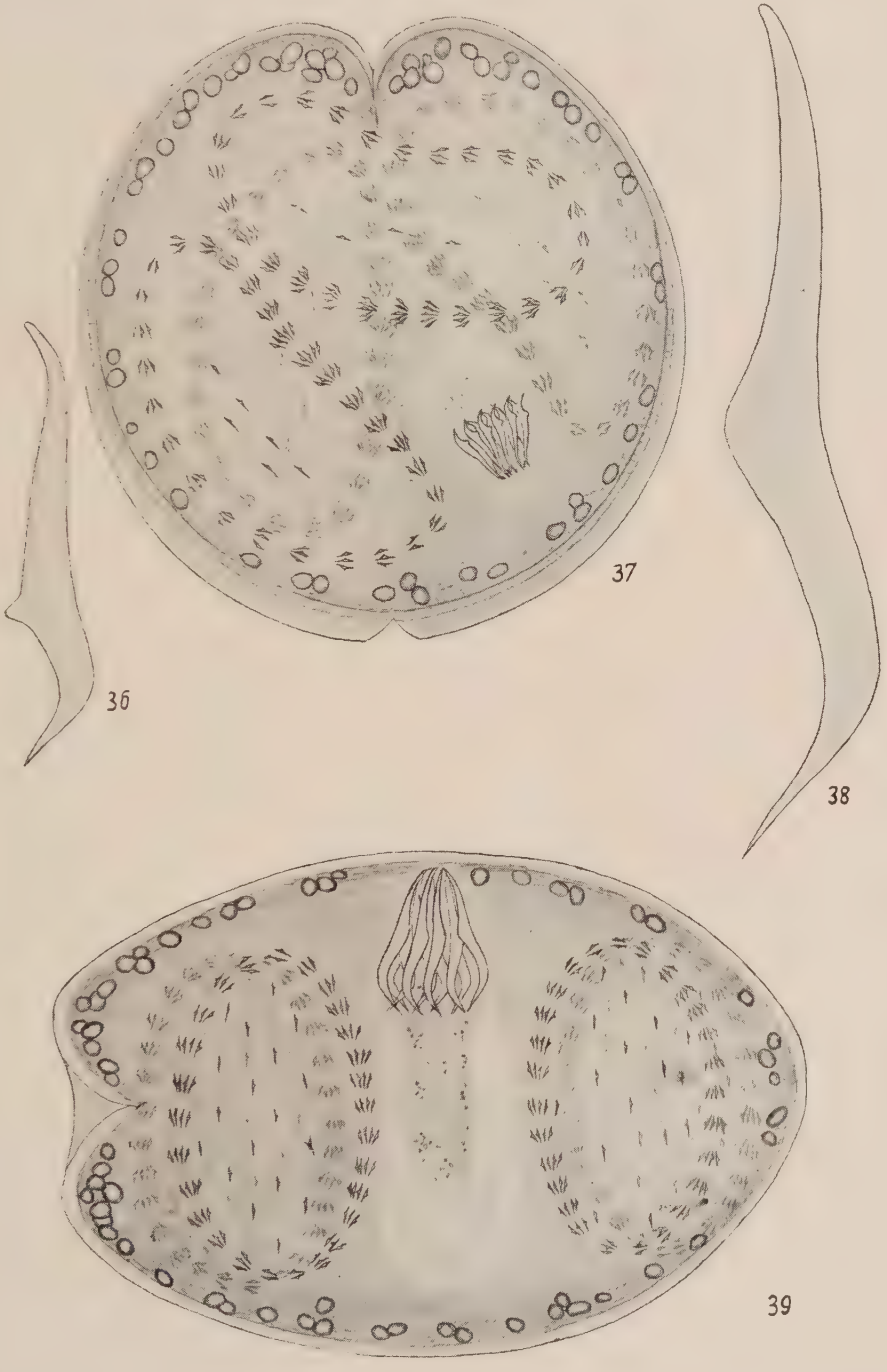

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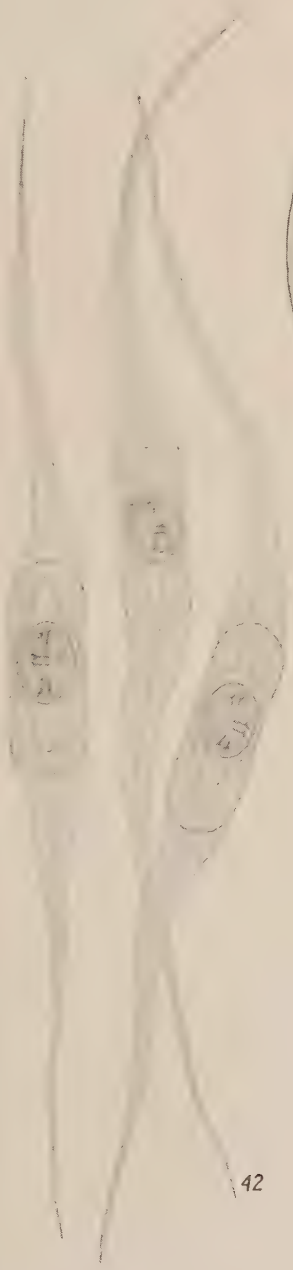

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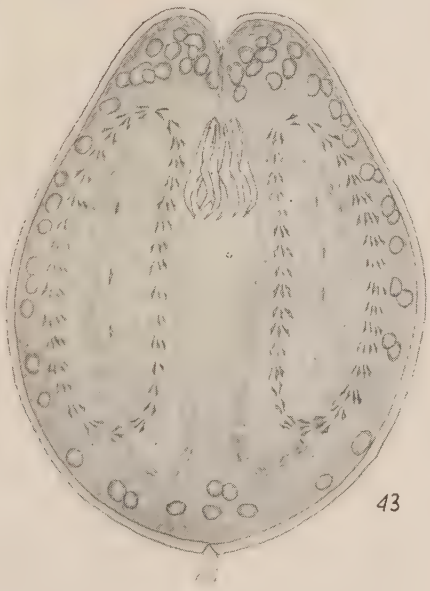

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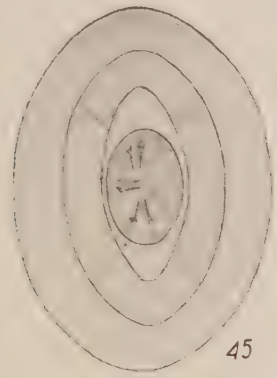

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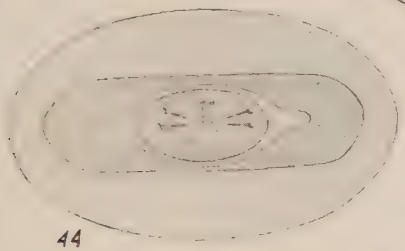

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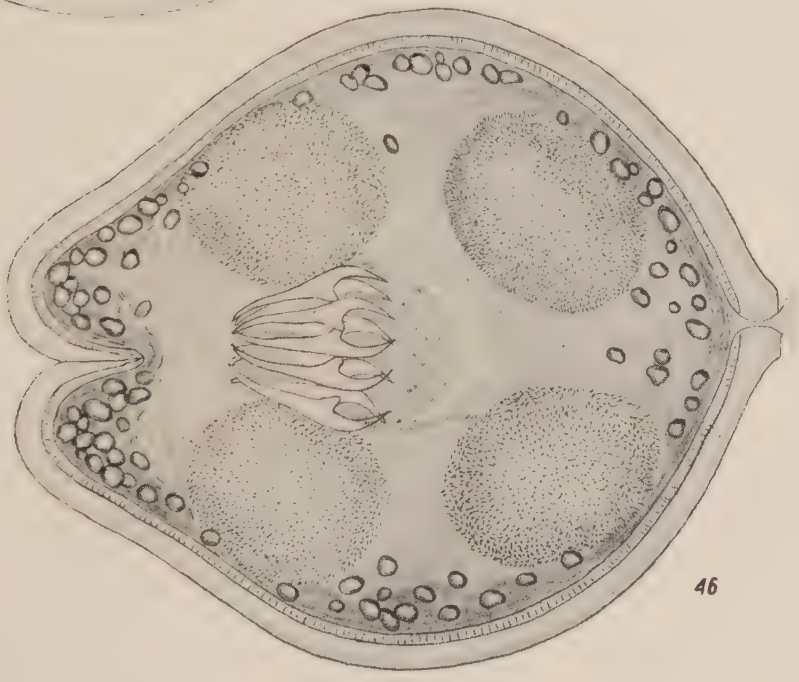

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their surfaces. The hooklets are arranged in the following manner: 4 rows of hooklets on the two elongated margins of the suckers and 3 rows at the poles. The arrangement of hooklets at the centre of the sucker resembles that of pawns on a chess-board. A large rostellum is armed with 10 large hooks. The shape and size of hooks resembles that of *Echinocotyle clerci*.

Dimensions of the cysticercoid: the cyst measures 0.28 by 0.23 mm, the suckers 0.12 by 0.072 mm. The hooks are 0.069 mm long. The hooklets on suckers measure 0.008 mm in length.

These cysticercoids differ from the cysticercoids of *Echinocotyle linstowi* described by Daday only in the length of hooks. The hooks of *Echinocotyle linstowi* measure 0.08 to 0.09 mm. The shape of hooks, however, is very similar. The hooks have no clearly developed tooth, while the handle and blade are of practically equal length.

The cysticercoids of *Echinocotyle linstowi* were found by Daday in *Diaptomus asiaticus* Ulj. and in *Diaptomus spinosus* Dad.

18. Cysticercoids of *Echinocotyle druzniensis* n. sp. in the naturally invaded plankton of Drużno Lake

(Plate X, Fig. 43)

The cysticercoids of *Echinocotyle druzniensis* are the most widely distributed larvae in the plankton of Drużno Lake (see Table II). In the examined plankton I found 47 cysticercoids in the following *Copepoda* species: 16 cysticercoids in *Macrocyclops albidus*, 13 in *Mesocyclops leuckarti*, 9 in *Acanthocyclops viridis*, 3 in *Eucyclops serrulatus*, 3 in *Eucyclops macrurus*, 1 in *Eucyclops macruroides*, 1 in *Eucyclops macruroides* var. *denticulatus* and 1 in *Mesocyclops oithonoides*. One cysticercoid occurred in each specimen of host, with the exception of *Acanthocyclops viridis* which harbored 9 cysticercoids in its body cavity.

The cysticercoids of *Echinocotyle druzniensis* have small ovoid cysts with thin walls. The inner shell of the scolex contains calcareous corpuscles. The scolex fills the entire cyst cavity. There are four, large oval suckers armed with hooklets that are typical of the *Echinocotyle*. The hooklets are arranged in the following way: 3 rows of hooklets on the inner margin of the sucker, 4 rows on the outer margin and 2 rows at each pole. In the centre of the sucker there are usually 4 hooklets although certain suckers bear 3 or

5 hooklets. The scolex bears 10 hooks of the nitidulans type. The handle of the hook and the blade are of equal size; there is no tooth.

Dimension of the cysticercoid: the cyst measures 0.18 by 0.15 mm, the suckers 0.10 by 0.032 mm. The length of hooks measures 0.042 mm. The hooklets on suckers are 0.0099 mm long.

No adult cestode with a similar scolex was found in the examined birds inhabiting Drużno Lake. A comparison of these scolices with the scolices of adult cestodes of the genus *Echinocotyle* described in literature led me to believe that they belong to an unknown species of tapeworm *.

19. Cysticercoids of *Diorchis ransomi* Schultz, 1940 in the naturally invaded plankton of Drużno Lake
(Plate XI, Fig. 47)

The investigated plankton contained 18 cysticercoids which on the basis of morphological comparison were identified as belonging to *Diorchis ransomi*. They occurred singly in three *Ostracoda* species: in *Cypridopsis vidua* — 9 cysticercoids; in *Cyclocypris laevis* — 6 cysticercoids; in *Cyclocypris ovum* — 3 cysticercoids.

The cysts of these cysticercoids are pear-shaped with a funnel-like invagination at the anterior end. The tail is short, the cyst walls thin and covered with a layer of transparent cuticle. The inner shell of the scolex contains numerous calcareous corpuscles. The scolex bears four slightly oval suckers. The surface of the suckers is covered with tiny spines, which are best visible on the margin of the sucker, where they are larger and more close to one another. The rostellum bears 10 hooks of identical shape and size as in an adult cestode.

The cyst measures an average of 0.23 by 0.21 mm, the suckers 0.072 by 0.060 mm. The length of hooks varies from 0.036 to 0.039 mm.

As has already been pointed out these cysticercoids do not differ from the experimentally obtained cysticercoids of *Diorchis parvogenitalis*. However, considering the intensity and extensity of invasion of the definitive hosts occurring in Drużno Lake at that time and also the successful results of the experimental proof of the life cycle of *Diorchis ransomi* done by Rybicka (18) I am inclined to con-

* In 1956 during our studies at Mamry Lake a tapeworm with a similar scolex was found in *Larus fuscus*.

clude that the majority of cysticercoids in natural invasion belonged to *Diorchis ransomi*.

Rybicka fed *Copepoda* and *Ostracoda* common in Drużno Lake on eggs of *Diorchis ransomi*. The results of experimental invasions fully confirm the finding on natural invasion. The experimental intermediate hosts are also *Cypridopsis vidua, Cyclocypris laevis* and *Cyclocypris ovum*.

20. Cysticercoids of *Diorchis inflata* (Rudolphi, 1819) in the naturally invaded plankton of Drużno Lake

(Plate XI, Fig. 46)

The cysticercoids of *Diorchis inflata* have been identified like those of *Diorchis ransomi* by comparison of their scolices with the scolices of adult worms occurring at that time in the definitive hosts inhabiting Drużno Lake and also by comparing them with the cysticercoids of *Diorchis inflata* experimentally obtained by Rybicka (18).

In the examined plankton of Drużno Lake I found 11 cysticercoids; 10 of them occurred singly in 10 specimens of *Cypridopsis vidua* and 1 in *Cyclocypris laevis*.

The cysts of these cysticercoids are pear-shaped and have a funnel-like invagination at the anterior end. No tails were observed. The cyst walls were thin and covered with a heavy layer of transparent cuticle. The inner shell of the scolex contains numerous calcareous corpuscles. The large scolex completely fills the entire cyst cavity. Four slightly oval suckers are covered with tiny spines. Like in cysticercoids of *Diorchis ransomi* the spines on the margins of the suckers are better visible and closer to one another. The 10 rostellar hooks are of identical shape and length as the hooks of an adult cestode.

The cyst measures an average of 0.30 by 0.27 mm, the suckers 0.096 by 0.082 mm. The length of hooks varied from 0.067 to 0.072 mm.

Rybicka proved experimentally the life cycle of *Diorchis inflata* by feeding on its eggs species of *Copepoda* and *Ostracoda* common in Drużno Lake. The results of the experiment are consistent with the findings of the studies of natural invasion. The experimental intermediate hosts are also *Cypridopsis vidua* and *Cyclocypris laevis*.

The cysticercoids of *Diorchis inflata* did not differ fundamentally from the several cysticercoids of *Diorchis stefańskii* obtained by me experimentally. No essential differences between them could be observed. The cysticercoids of *Diorchis stefańskii* had only slightly larger and more oval suckers.

Observations and conclusions

The investigation enabled me to make the following observations and draw certain general conclusions.

1. Quantitative collecting of plankton crustaceans revealed a small percentage of naturally invaded plankton (see Table II). Since nearly the whole area of Drużno Lake constitutes a littoral rich in water plants, and a differentiation of plant communities goes in hand with a quantitative and systematic differentiation of plankton. the qualitative method of collecting gave better and quicker results. Moreover the qualitative method of collecting was suitable for finding the „foci" of invasion in the plankton inhabiting the lake. These „foci" were located mostly in very shallow places, or small bays at the lakeshore, rich in aquatic plants (mostly *Lemna trisulca* and *Ceratophyllum*) and sufficiently protected from waves. In such places *Copepoda* and *Ostracoda*, which were the main intermediate hosts of cestodes parasitic in *Anatidae* and *Fulica atra* (L.), occurred in greatest quantities. At the same time such places were often frequented by the definitive hosts.

The „focus-like" character of invasion and the fact that the main intermediate hosts of duck and coot (*Fulica atra*) tapeworms are *Copepoda* and *Ostracoda* (*Macrocyclops albidus, Acanthocyclops viridis, Cypridopsis vidua, Cyclocypris laevis*) typical of environments suitable for contacts with the definitive hosts are undoubtelly adaptations in the life cycle of these cestodes.

2. The natural and experimental invasion of *Copepoda* and *Ostracoda* inhabiting Drużno Lake shows that the common and well represented species of crustaceans are at the same time the main intermediate hosts of a number of cestodes common in the definitive hosts associated with Drużno Lake. These numerous and common species of Drużno *Copepoda* are: *Macrocyclops albidus, Acanthocyclops viridis,* and *Mesocyclops leuckarti. Macrocyclops albidus* is the main intermediate host of the following cestodes: *Diploposthe laevis, Diploposthe skrjabini, Fimbriaria fasciolaris, Fimbriarioides*

intermedia, Hymenolepis paracompressa, Hymenolepis spiralibursata, and *Hymenolepis paramicrosoma.*

The most numerous and common *Ostracoda* occurring in Drużno Lake were: *Cypridopsis vidua* and *Cyclocypris laevis.* They are mainly the intermediate hosts of species belonging to the genus *Diorchis,* namely: *Diorchis ransomi, Diorchis inflata, Diorchis nyrocae,* and *Diorchis parvogenitalis.*

3. The species composition of larvae found in the naturally invaded plankton of Drużno Lake is consistent with the composition of cestode species common and widely occurring in the examined definitive hosts (*Anatidae* and *Fulica atra*). The cysticercoids of *Echinocotyle druzniensis* n. sp., which were found quite often, are an exception; their adult form was not found in the examined birds. Neither was the adult form of two specimens of cysticercoids of *Echinocotyle clerci,* ever found in the examined definitive hosts.

4. I succeeded in tracing experimentally the life cycles of 11 species of cestodes parasitic in ducks of Drużno Lake. The experiment consisted of feeding various *Copepoda* and *Ostracoda* on eggs of these cestodes.

The results of experimental invasion confirmed the relations observed in natural invasion and, on the other hand, the life cycle of these tapeworms was discovered not only under experimental conditions but also in the natural biocoenosis of Drużno Lake.

5. The ways of circulation of cestodes in different natural environments may vary depending on the numbers and frequency of occurrence of the main and auxiliary intermediate hosts and on their availability to the definite hosts in the community. It, therefore, seems appropriate to study the life cycle of cestodes in specific conditions of a given biocoenosis. The extensity and intensity of invasion of definitive hosts occurring in or associated with a particular environment may depend on the ways of circulation. For instance *Anas platyrhynchos* inhabiting Drużno Lake was extensively and highly invaded with *Hymenolepis paracompressa* and *Hymenolepis spiralibursata.* The number of these tapeworms in a particular duck could exceed ten thousand (Data on the invasion of definitive hosts taken from C z a p l i ń s k i and R y b i c k a). The natural and experimental invasion of *Copepoda* with cysticercoids of both these cestodes species proves that their main intermediate host is *Macrocyclops albidus* and the secondary intermediate hosts are *Acanthocyclops viridis* and *Mesocyclops leuckarti,* which are also the inter-

mediate hosts of other much less numerous cestodes parasitic in *Anas platyrhynchos* associated with Drużno Lake such as *Hymenolepis paramicrosoma,* and *Hymenolepis compressa.* The intensity and extensity of the natural invasion of *Gastropoda (Radix ovata, Radix auricularia, Radix ampla)* examined at that time at Drużno with cysticercoids of *Hym. paracompressa* and *Hym. spiralibursata* shows that the main part in the circulation of tapeworms in Drużno Lake is played by the *Gastropoda. Copepoda* are rather of secondary importance. The cysticercoids in naturally invaded *Copepoda* are more dispersed while the *Gastropoda* are more available to the definitive hosts. One may conclude that passing through *Gastropoda* is the cause of intensity and extensity of *Anas platyrhynchos* invasion with the two tapeworms species since the intensity and extensity of invasion of *Anas platyrhynchos* with tapeworms passing only through *Copepoda (Hym. paramicrosoma, Hym. compressa)* is much smaller (Czapliński).

The life cycle of *Sobolevicanthus gracilis* found in Drużno Lake may serve as another example. None of the intermediate hosts reported in literature *(Diaptomus spinosus, Diaptomus vulgaris, Acanthocyclops viridis, Eucypris virens, Cyclocypris dispersa, Cyclocypris globosa, Potamocypris ophtalmica, Candona compressa, Candona rostrata, Candona neglecta, Dolerocypris fasciata)* participated in the circulation of this cestode since they either do not occur in Drużno Lake or occur in very small numbers (they were not found in the examined samples). The intermediate host of *Sobolevicanthus gracilis* at Drużno Lake is a common ostracode, *Cypridopsis vidua.*

6. While tracing the life cycles experimentally the following observations were made:

a. The results of experimental invasion of cestodes enumerated in this work confirm the existence of different groups of intermediate hosts reported by Michajłow (12). In this paper I am distinguishing only the main (group V) and secondary (group IV and III) intermediate hosts.

b. The eggs of each species of cestodes have a characteristic shape due to the form of the egg shell.

In eggs crowding the uterus the shell is creased and hardly noticeable. In contact with water it straightens out and becomes responsible for the final shape of eggs and certain properties connected with it, such as floating in water or settling on water plants.

I observed that the shape of eggs may give a hint as to the prospective intermediate host. Tapeworms having eggs of similar shapes often develop in the same species of intermediate hosts. For example *Cypridopsis vidua* is the main intermediate host of cestodes belonging to the genus *Diorchis* whose eggs have an elongated egg shell *(Diorchis nyrocae, Diorchis ransomi, Diorchis inflata). Cypridopsis vidua* was found most often and in large quantities among *Ceratophyllum*. Living among these plants and searching for food the copepods have a chance to ingest the eggs, which due to the shape and properties of their shell tend to settle on these plants.

c. In summer the development of cysticercoids in intermediate hosts under experimental conditions lasts 14 days. Lowering the temperature to 4°C inhibits the rate of growth and development of these cysticercoids.

d. While describing the cysticercoids of 18 species of cestodes, I observed that the most essential taxonomical feature of a cysticercoid is the scolex and its armature, and in particular the shape, number and size of rostellar hooks and the armature of the suckers. In many cases a morphological comparison of the scolex of a cysticercoid with the scolex of an adult worm could serve to establish the species affiliation of the larvae found in natural invasion.

The shape of cysts of cysticercoids is constant, but cannot be considered a diagnostic feature of a species. The cysts of different species of cysticercoids may have a similar or identical shape and structure as, for example, the cysts of cysticercoids of *Diploposthe* and *Fimbriaria.*

The size of cysts is in some species more or less constant and in no way related to the number of larvae occurring in the body cavity of an intermediate host, while in others, it varies within fairly large limits depending on the number of larvae in a host, and, possibly, on the living conditions of the intermediate host during growth and development of the larvae. For instance, the cysticercoids of *Hym. paracompressa* and *Hym. spiralibursata* found in naturally invaded *Copepoda* have larger cysts than the cysticercoids in experimental invasions.

The wall thickness of cysticercoid cysts may vary in certain species and this variation depends on the species of intermediate host. The cysticercoids of *Diploposthe laevis, Diploposthe skrjabini* and *Fimbriarioides intermedia* undergoing development in the body

cavity of *Macrocyclops albidus* have thin-walled cysts while the ones developing in the body cavity of *Macrocyclops fuscus* have thick-walled cysts.

Following the successive stages of growth and development of *Diploposthe skrjabini* cysticercoids in the body cavity of two species of hosts, I observed that the thickness of cyst walls is not related to the time a larva remains in the intermediate host, but depends on the intensity of her growth preceding the differentiation of structure.

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STRESZCZENIE

Skorupiaki planktonowe *(Copepoda, Ostracoda* i *Cladocera)* jeziora Drużno badano w celu poznania ich roli jako żywicieli pośrednich tasiemców. Zbierano je w jeziorze metodą ilościową i jakościową, przy czym metoda jakościowa, w związku z ogniskowością zarażenia, dawała pełniejsze i szybsze wyniki.

Ogółem zbadano 48 619 osobników, należących do 13 gatunków *Copepoda*, 4 gatunków *Ostracoda* oraz kilkunastu gatunków *Cladocera*.

W zbadanym materiale znaleziono 228 larw pasożytów, w tym: 10 metacerkarii *Bunodera luciopercae* Müller, 1776, 2 metacerkarie *Gorgodera cygnoides* (Zeder) i 216 larw tasiemców. Spośród nich tylko 4 były typu procerkoidu — 2 procerkoidy *Ligula intestinalis* (Linné) i 2 *Triaenophorus lucii* (Müller). Pozostałe larwy były cysticerkoidami 16 gatunków tasiemców, pasożytujących

u *Anatidae* i *Fulica atra* L. Wyróżniono cysticerkoidy następujących gatunków tasiemców: *Hym. compressa* (Linton, 1892); *Hym. paracompressa* Czapliński, 1956; *Hym. spiralibursata* Czapliński, 1956; *Hym. paramicrosoma* Gąsowska, 1931; *Dicranotaenia coronula* (Duj., 1854), *Sobolevicanthus gracilis* (Zeder, 1803), *Sobolevicanthus bisaccata* (Fuhrm., 1906); *Echinocotyle rosseteri* Blanch., 1891; *Echinocotyle clerci* Mathevossian et Krotov, 1949; *Echinocotyle druzniensis* n. sp.; *Fimbriaria fasciolaris* (Pall., 1781); *Fimbriarioides intermedia* (Furm., 1913); *Diploposthe laevis* (Bloch, 1782); *Diploposthe skrjabini* Mathevossian, 1945; *Diorchis ransomi* Schultz, 1940; *Diorchis inflata* (Rudolphi, 1819); *Diorchis nyrocae* Yamaguti, 1935.

Skład gatunkowy larw znalezionych w zarażeniu naturalnym zbadanego planktonu jest zgodny ze składem gatunkowym tasiemców pospolicie i licznie występujących w żywicielach ostatecznych (*Anatidae* i *Fulica atra*). Wyjątek stanowią cysticerkoidy *Echinocotyle druzniensis* n. sp., których postaci dorosłej w zbadanych na jeziorze Drużno ptakach nie znaleziono.

Równocześnie przeprowadzano cykle rozwojowe drogą eksperymentalną, zarażając jajami tasiemców kaczek pospolite gatunki *Copepoda* i *Ostracoda* z jeziora Drużno. Wyniki eksperymentalnego zarażenia potwierdziły stosunki zaobserwowane w zarażeniu naturalnym, a jednocześnie cykl rozwojowy tych tasiemców został poznany nie tylko w warunkach eksperymentu, lecz również w warunkach naturalnych na jeziorze Drużno. Eksperymentalnie badano rozwój 13 gatunków tasiemców, z tego dla 11 gatunków uzyskano pozytywny wynik zarażenia. Są to rozwoje następujących gatunków tasiemców: *Hym. paracompressa* Czapliński, 1956; *Hym. spiralibursata* Czapliński, 1956; *Hym. paramicrosoma* Gąsowska, 1931; *Dicranotaenia coronula* (Duj., 1854); *Sobolevicanthus gracilis* (Zeder, 1803); *Diploposthe laevis* (Bloch, 1782); *Diploposthe skrjabini* Mathevossian, 1945; *Fimbriaria fasciolaris* (Pall., 1781); *Fimbriarioides intermedia* (Fuhrm., 1913); *Diorchis nyrocae* Yamaguti, 1935; *Diorchis parvogenitalis* Skrjabin et Mathevossian, 1945.

Naturalne i eksperymentalne zarażenie gatunków *Copepoda* i *Ostracoda* jeziora Drużno wykazuje, że pospolite i licznie reprezentowane gatunki *Copepoda* i *Ostracoda* — *Macrocyclops albidus* (Jur.), *Acanthocyclops viridis* (Jur.), *Mesocyclops leuckarti* (Claus), *Cypridopsis vidua* (O. F. Müller) i *Cyclocypris laevis* (O.

F. Müller) są głównymi żywicielami pośrednimi tasiemców pospolicie i licznie występujących w żywicielach ostatecznych na jeziorze Drużno (*Anatidae* i *Fulica atra*). *Macrocyclops albidus* jest głównym żywicielem pośrednim tasiemców: *Diploposthe laevis, Diploposthe skrjabini, Fimbriaria fasciolaris, Fimbriarioides intermedia, Hym. paracompressa, Hym. spiralibursata, Hym. paramicrosoma.* Z *Ostracoda Cyprydopsis vidua* i *Cyclocypris laevis* były żywicielami pośrednimi, przede wszystkim, gatunków z rodzaju *Diorchis*, jak: *D. nyrocae, D. parvogenitalis, D. ransomi, D. inflata.*

Autorka stawia i ilustruje przykładami tezę słuszności badania cyklów rozwojowych tasiemców w odniesieniu do warunków naturalnych, gdyż cykle rozwojowe tasiemców w różnych naturalnych środowiskach mogą przebiegać różnymi drogami w zależności od liczebności i pospolitości występowania głównych i pomocniczych żywicieli pośrednich oraz od ich dostępności w danym środowisku dla żywicieli ostatecznych. Od przebiegu drogi krążenia zależy intensywność i ekstensywność zarażenia żywicieli ostatecznych w danym środowisku.

Przeprowadzając rozwoje drogą eksperymentalną autorka zanotowała następujące spostrzeżenia:

a. Wyniki eksperymentalnego zarażenia potwierdzają istnienie różnych grup żywicieli pośrednich wyróżnionych przez Michajłowa (1938). W pracy tej ograniczono się do podania żywicieli pośrednich głównych i pomocniczych.

b. Jaja poszczególnych gatunków tasiemców mają charakterystyczny kształt, który im nadaje otoczka jajowa. Otoczka jajowa u jaj stłoczonych w macicy jest zgnieciona i słabo dostrzegalna. W wodzie rozprostowuje się nadając jajom ostateczny kształt i związane z nim właściwości, takie jak unoszenie się w wodzie lub zatrzymywanie się na roślinach wodnych. Kształt jaj może być wskazówką przy badaniu cyklu rozwojowego, gdyż tasiemce o podobnym kształcie jaj rozwijają się w tych samych gatunkach żywicieli pośrednich.

c. Opisując cysticerkoidy 19 gatunków tasiemców autorka stwierdziła, że najistotniejszymi cechami taksonomicznymi cysticerkoidów jest skoleks i jego uzbrojenie, w szczególności kształt, ilość i wielkość haków na rostellum, oraz uzbrojenie przyssawek.

EXPLANATION OF PLATES

The dimensions of eggs and cysticercoids is equally magnified in all the drawings. Single rostellar hooks are magnified more than the eggs and cysticercoids, but the magnification has been kept constant for all the hooks.

Plate I

Diploposthe laevis (Bloch, 1782). 1. Embryonal hooks; 2. Eggs directly shed from the uterus; 3. Eggs in water; 4. Oncosphere in the body cavity of an intermediate host.

Plate II

Diploposthe skrjabini Mathevossian, 1945. 5. Larva on the 5th day of development in the body cavity of *Macrocyclops fuscus*; 6. Larva on the 5th day of development in the body cavity of *Macrocyclops albidus*; 7. Larva on the 10th day of development in the body cavity of *Macrocyclops albidus*; 8. Larva on the 10th day of development in the body cavity of *Macrocyclops fuscus*.

Plate III

9. Rostellar hook of a cysticercoid of *Diploposthe laevis*; 10. Cysticercoid of *Diploposthe skrjabini* from the body cavity of *Macrocyclops albidus*; 11. Cysticercoid of *Diploposthe skrjabini* from the body cavity of *Macrocyclops fuscus*.

Plate IV

12. Eggs of *Hymenolepis paracompressa* Czapliński, 1956; 13. Rostellar hook of a cysticercoid of *Hymenolepis paramicrosoma* Gąsowska, 1931; 14. Cysticercoid of *Hymenolepis paramicrosoma*; 15. Rostellar hook of *Hymenolepis spiralibursata* Czapliński, 1956; 16. Cysticercoid of *Hymenolepis spiralibursata*; 17. Rostellar hook of a cysticercoid of *Hymenolepis compressa* (Linton, 1892).

Plate V

18. Cysticercoid of *Hymenolepis paracompressa* Czapliński, 1956; 19. Rostellar hook of a cysticercoid of *Hymenolepis paracompressa*.

Plate VI

20. Cysticercoid of *Sobolevicanthus bisaccata* (Fuhrm., 1906); 21. Rostellar hook of a cysticercoid of *S. bisaccata*; 22. Cysticercoid of *Fimbriaria* without hooks; 23. Cysticercoid od *Fimbriarioides intermedia* (Fuhrm., 1913) from the body cavity of *Macrocyclops fuscus;* 24. Eggs of *Hymenolepis teresoides* Furm., 1906.

Plate VII

25. Eggs of *Fimbriarioides intermedia* (Fuhrm., 1913); 26. Eggs of *Fimbriaria fasciolaris* (Pall., 1781); 27. Cysticercoid of *Fimbriaria fasciolaris*; 28. Rosteller hook of a cysticercoid of *Fimbriaria fasciolaris*; 29. Cysticercoid of *Fimbriarioides intermedia* from *Macrocyclops albidus*; 30. Rostellar hook of a cysticercoid of *F. intermedia*.

Plate VIII

31. Cysticercoid of *Sobolevicanthus gracilis* (Zed., 1803); 32. Rostellar hook of a cysticercoid of *S. gracilis;* 33. Cysticercoid of *Dicranotaenia coronula* (Duj., 1845); 34. Rostellar hook of a cysticercoid of *D. coronula;* 35. Egg of *S. gracilis*.

Plate IX

36. Rostellar hook of a cysticercoid of *Echinocotyle rosseteri* Blanch., 1891; 37. Cysticercoid of *E. rosseteri*; 38. Rostellar hook of a cysticercoid of *E. clerci* Mathevossian et Krotov, 1949; 39. Cysticercoid of *E. clerci*.

Plate X

40. Cysticercoid of *Diorchis nyrocae* Yamaguti, 1935; 41. Rostellar hook of a cysticercoid of *D. nyrocae;* 42. Egg of *D. nyrocae;* 43. Cysticercoid of *Echinocotyle druzniensis* n. sp.

Plate XI

44. Egg of *Diorchis stefańskii* Czapliński, 1956; 45. Egg of *D. parvogenitalis* Skrjabin et Mathevossian, 1945; 46. Cysticercoid of *D. inflata* (Rud., 1891); 47. Cysticercoid of *D. parvogenitalis*.